



Budget Estimates

FISCAL YEAR **1982**

Volume I

Agency Summary

Research and Development

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1982 ESTIMATES

VOLUME I

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National Aeronautics and Space Administration
Washington, D.C. 20546

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AGENCY
SUMMARY

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1982 BUDGET ESTIMATES

GENERAL STATEMENT

The National Aeronautics and Space Administration, established October 1, 1958, conducts space and aeronautics activities for peaceful purposes for the benefit of all. NASA's activities are designed to maintain United States leadership in aeronautical and space research and technology and its utilization. More specifically, the objectives of NASA activities are to:

- Extend our knowledge of the Earth, its environment, the solar system, and the universe;
- Expand the practical applications of space technology;
- Develop, operate, and improve manned and unmanned space vehicles;
- Improve the civil and military usefulness of aeronautical vehicles, while minimizing their environmental effects and energy consumption;
- Disseminate pertinent findings to potential users; and
- Promote international cooperation in peaceful activities in space.

The NASA FY 1982 budget recommendation of \$6,725.7 million provides for progress toward achievement of these objectives at a pace consistent with a constrained fiscal environment.

Space program elements in the recommended budget provide for progress in development of the operational capability and use of the Space Shuttle and related systems; in practical application of space capabilities in remote sensing of land, ocean, and atmospheric conditions, in materials processing, and in communications; in exploration of the solar system and expansion of our knowledge of the universe; and in advancing the technology necessary for United States leadership in space. Major areas of emphasis include:

- Development, qualification, and flight testing of the Space Shuttle and manufacture of orbiter vehicles on a schedule consistent with the requirements of the Department of Defense and civil users. The Space Shuttle is progressing toward the initial orbital flight test scheduled for March 1981. Additional orbital flight tests are

scheduled during FY 1981 and 1982 leading to an operational capability in late 1982. The Space Shuttle, the first reusable Earth-to-orbit transport vehicle, will be the key element in the space transportation system which will also include upper stages to provide high altitude orbit and planetary capability, and the Spacelab being developed by the European Space Agency to provide a new capability for conducting experiments in space. This space transportation system will provide the basic capability for a new era of operations in and utilization of space.

- Space science flight missions and research and analysis to expand human knowledge of the Earth's environment, the solar system and the universe. Specifically, work will continue on the Galileo orbiter and probe mission to Jupiter as the next step after Voyager in exploration of the outer planets; on the International Solar Polar Mission to obtain new knowledge of the Sun; on the Space Telescope to provide a quantum jump in our ability to observe the universe; and on the Gamma Ray Observatory to study extremely high energy phenomena. The Venus Orbiting Imaging Radar will continue exploration of the inner planets and is included as a new initiative in FY 1982.

- Space applications flight missions and ground-based activities to make practical use of space capabilities in meeting needs on Earth. For example, in FY 1982 work will continue in preparation for launch of the Landsat-D spacecraft to extend and improve Earth resources observations from space; on the Earth Radiation Budget Experiments spacecraft to measure the exchange of energy between the Earth and space; on the search and rescue locator system to be flown on weather satellites; and on the National Oceanic Satellite System to provide global sensing of ocean conditions. Preparation for materials processing experiments taking advantage of the space environment research in advanced satellite communications, and activities to transfer technology to nonaerospace sectors of the economy are also part of the applications program.

- Space research and technology activities emphasizing the longer range aspects of technology which are crucial to future United States leadership in space.

Aeronautical research and technology activities in the recommended budget are necessary to advance the aeronautical technology base for safer, more economical, efficient and environmentally acceptable air transportation systems which are responsive to current and projected national needs; to maintain the strong competitive position of the United States in the international aviation marketplace; and to support the military in maintaining the superiority of the Nation's military aircraft. The FY 1982 program continues emphasis on the fundamental research and technology base in all disciplines vital to aeronautics; on specific technology efforts directed toward major improvements in transport aircraft energy efficiency and on systems technology to provide a basis for improved performance and safety for future vehicles in each major aircraft category. The FY 1982 budget provides for initiation of development of the Numerical Aerodynamics Simulator, a major new and unique capability in the field of computational fluid dynamics. This new national resource will have a major impact on aircraft design methods as well as on large-scale computer design technology in this country.

Resources Summary

The budget authority recommended for FY 1982 totals \$6,725.7 million with estimated outlays of \$6,363.4 million and a civil service staffing level of 22,713.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

BUDGET SUMMARY (Thousands of Dollars)

	Budget Plan		
	FY 1980	FY 1981	FY 1982
<u>RESEARCH AND DEVELOPMENT</u>			
<u>Space Transportation Systems..</u>	<u>2,385,000</u>	<u>2,681,100</u>	<u>3,304,200</u>
Space Shuttle.....	1,871,000	1,943,000	2,230,000
Space flight operations.....	446,600	683,700	1,043,000
Expendable launch vehicles.....	67,400	54,400	31,200
<u>Space Science.....</u>	<u>600,500</u>	<u>562,488</u>	<u>756,700</u>
Physics and astronomy.....	336,800	344,700	451,400
Planetary exploration.....	219,900	175,600	256,100
Life sciences.....	43,800	42,188	49,200
<u>Space and Terrestrial Applications.....</u>	<u>343,600</u>	<u>365,350</u>	<u>487,500</u>
Space applications.....	331,620	353,550	472,900
Technology utilization.....	11,980	11,800	14,600
<u>Aeronautics and Space Technology..</u>	<u>426,886</u>	<u>390,750</u>	<u>469,000</u>
Aeronautical research and technology.	308,300	276,150	323,600
Space research and technology.....	115,586	110,700	141,000
Energy technology	3,000	3,900	4,400
<u>Tracking and Data Acquisition.....</u>	<u>332,100</u>	<u>341,100</u>	<u>435,200</u>
TOTAL RESEARCH AND DEVELOPMENT.....	4,088,086	4,340,788	5,452,600
<u>CONSTRUCTION OF FACILITIES.....</u>	<u>159,100</u>	<u>115,000</u>	<u>136,800</u>
<u>RESEARCH AND PROGRAM MANAGEMENT.....</u>	<u>995,968</u>	<u>1,081,400^{a/}</u>	<u>1,136,300</u>
TOTAL.....	<u>5,243,154</u>	<u>5,537,188</u>	<u>6,725,700</u>
<u>OUTLAYS</u>	<u>4,851,637</u>	<u>5,286,000</u>	<u>6,363,400</u>

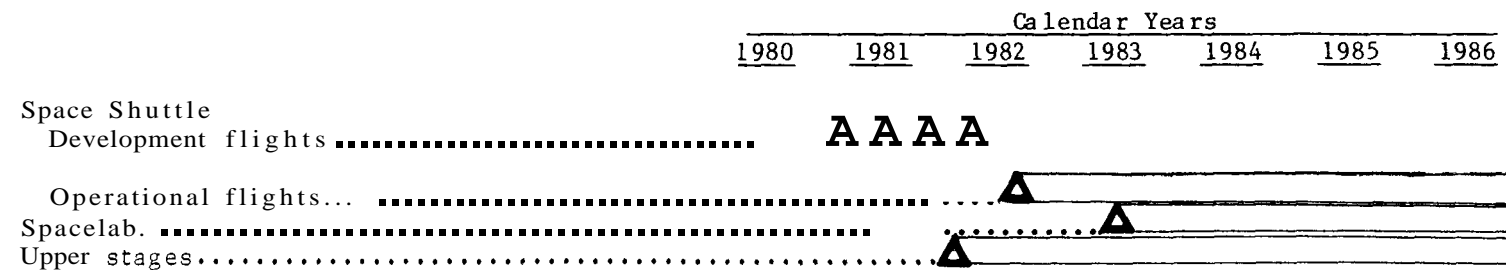
^{a/} Includes proposed supplemental of \$51,400,000 for October 1980 pay raise.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPACE TRANSPORTATION SYSTEMS

- Develop a versatile space transportation system to provide for:
 - Expanded capabilities employing the reusable Space Shuttle system
 - Manned orbital experiments using Shuttle and Spacelab
 - Deep space and geosynchronous mission capability with upper stages
 - Orbital placement, servicing, and retrieval of automated satellites
 - Economy in transportation, space operations, and payload costs
- Continue production to provide a national fleet of Space Shuttle orbiters
- Conduct Shuttle orbital flight tests during FY 1981 and 1982
- Establish capability for space transportation system operations to begin in 1982
- e Develop the Solar Electric Propulsion System as an advanced upper stage
- Provide expendable launch vehicle services as required by NASA and other users during transition to the space transportation system

MAJOR FLIGHT ACTIVITY

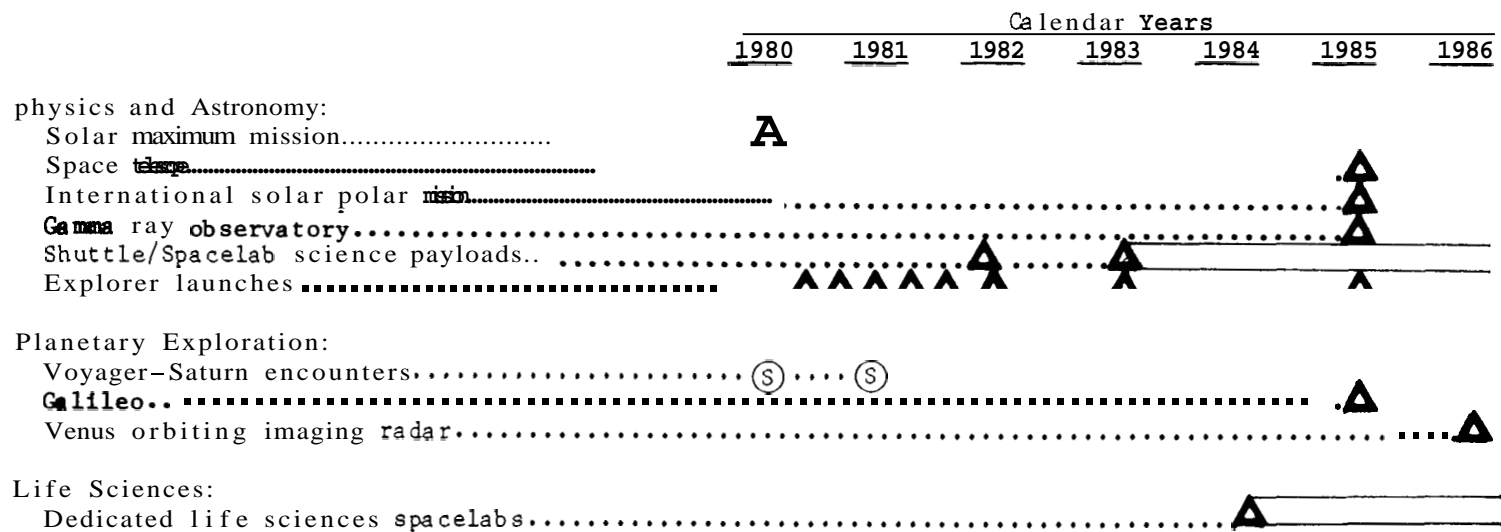


NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPACE SCIENCE

- Increase our understanding of the evolution and nature of the Earth and its environment, the solar system, and the universe through a balanced program of space exploration missions and ground-based investigations
- Exploit the knowledge gained from current and completed program efforts by thorough analysis and interpretation of the scientific data obtained
- Utilize the space environment for research in the biomedical, biological, and bioinstrumentation fields

MAJOR FLIGHT ACTIVITY

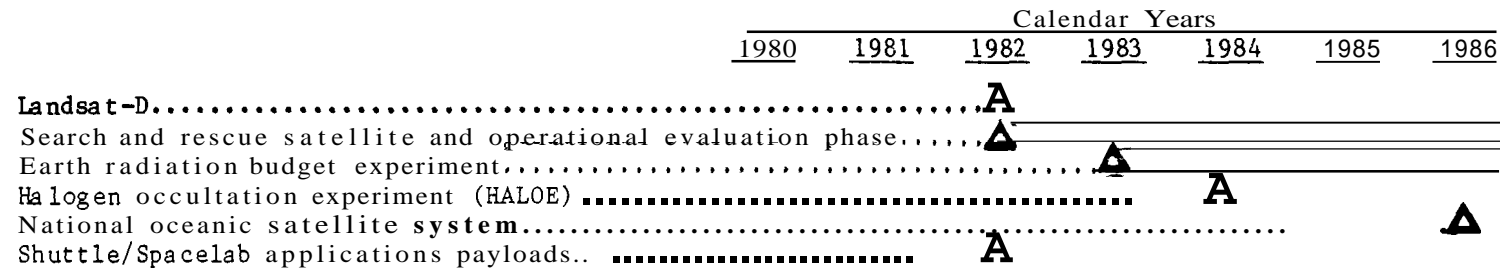


NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPACE AND TERRESTRIAL APPLICATIONS

- Develop and demonstrate practical uses of space and space-derived technology
 - Remote sensing of Earth resources
 - Environmental observations from space
 - Materials processing in space
 - Space communications
- Accelerate the transfer of NASA-developed research and technology advances to public and private sectors

MAJOR FLIGHT ACTIVITY



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

AERONAUTICAL RESEARCH AND TECHNOLOGY

- Provide a technology base for current and future civil and military aircraft to:
 - Reduce energy requirements
 - Improve performance
 - Increase safety
 - Decrease environmental effects
 - Reduce costs
- Achieve these objectives, by means of ground and flight-based research and technology activities, through advances in the technology areas of:
 - Materials and structures
 - Propulsion
 - Avionics and flight control
 - Aerodynamics
 - Operations
 - Human-vehicle interactions
- Major technology efforts:
 - Technology for energy efficiency in transport aircraft
 - Numerical aerodynamic simulator

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPACE RESEARCH AND TECHNOLOGY

- Provide a technology base essential to future United States leadership in space by:
 - Imprwng performance and effectiveness
 - Reducing cost and risk
 - Increasing reliability
 - Developing technological options
- Achieve these objectives, by means of ground and space-based research and technology activities, through advances in the technology areas of:
 - Aerothermodynamics
 - Materials and structures
 - Electronics and automation
 - Chemical and electric propulsion
 - Space power systems
 - Component standardization
 - Spacecraft, transportation, and informtion systems

MAJOR FLIGHT ACTIVITY

	Calendar Years						
	<u>1980</u>	<u>1981</u>	<u>1982</u>	<u>1983</u>	<u>1984</u>	<u>1985</u>	<u>1986</u>
Space technology Shuttle/Spacelab payloads..						A

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

ENERGY TECHNOLOGY

- Energy technology activities to facilitate use of NASA-developed aerospace technologies, experience and facilities to meet the program needs of the Department of Energy and other agencies responsible for energy programs

TRACKING AND DATA ACQUISITION

- Worldwide networks of ground stations interconnected with highly reliable communications to provide support to:
 - Shuttle orbital flight tests
 - Automated Earth orbiting missions - an average of forty applications and scientific spacecraft will be supported including the Nimbus, Landsat-D, International Ultraviolet Explorer, International Sun Earth Explorer, High Energy Astronomy Observations, Application Technology Satellites, International Solar Maximum Mission, Infrared Astronomical Satellite, Dynamics Explorer, and Solar Mesospheric Explorer
 - Planetary missions - support will continue for Pioneers 10 and 11 and Voyagers 1 and 2 as well as limited support for Viking, Helios, and earlier Pioneer missions
 - Sounding rockets
 - Aeronautical flight research program

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1982 ESTIMATES

SUMMARY OF APPROPRIATIONS

(Thousands of Dollars)

<u>Appropriations</u>	<u>FY 1980</u>	<u>FY 1981</u>	<u>FY 1982</u>
<u>Research and Development</u>	<u>4,088,086</u>	<u>4,340,788</u>	<u>5,452,600</u>
Basic appropriation.	3,807,500	4,396,200	5,452,600
Supplemental for Space Shuttle.	285,000	---	---
Recissions (PL 96-304 and PL 96-526)	- 1,414	-55,412	---
Transferred to Construction of Facilities.....,....	-3,000	---	---
<u>Construction of Facilities</u>	<u>159,100</u>	<u>115,000</u>	<u>136,800</u>
Basic appropriation.....	156,100	115,000	136,800
Transferred from Research and Development.	3,000	---	---
<u>Research and Program Management</u>	<u>995,968</u>	<u>1,081,400</u>	<u>1,136,300</u>
Basic appropriation.	959,900	1,030,000	1,136,300
Unobligated balance lapsing.	-218	---	-
Supplemental appropriation for civilian pay raises, PL 96-304..	36,286	---	---
Proposed supplemental for civilian pay raises.....	---	51,400	---
Total.	<u>5,243,154</u>	<u>5,537,188</u>	<u>6,725,700</u>

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1982 ESTIMATES

SUMMARY RECONCILIATION OF APPROPRIATIONS TO BUDGET PLANS
(Thousands of Dollars)

<u>Fiscal Year 1980</u>	<u>Total</u>	<u>Research and Development</u>	<u>Construction of Facilities</u>	<u>Research and Program Management</u>
Appropriation, PL 96-103.. .. .	4,923,500	3,807,500	156,100	959,900
Rescission, PL 96-304.. .. .	-1,414	-1,414	---	---
Supplemental Appropriation, PL 96-304.. .. .	321,286	285,000	---	36,286
Transfer between accounts.. .. .	---	3,000	+3,000	---
Unobligated balance lapsing.. .. .	-218	---	---	-218
Total Budget Plan.. .. .	<u>5,243,154</u>	<u>4,088,086</u>	<u>159,100</u>	<u>995,968</u>
 <u>Fiscal Year 1981</u>				
Appropriation, PL 96-526.. .. .	5,541,200	4,396,200	115,000	1,030,000
Rescission, PL 96-526.. .. .	-55,412	-55,412	---	---
Proposed supplemental for civilian pay raises.. .. .	51,400	---	---	51,400
Total Budget Plan.. .. .	<u>5,537,188</u>	<u>4,340,788</u>	<u>115,000</u>	<u>1,081,400</u>
 <u>Fiscal Year 1982</u>				
Appropriation request/budget plan.. .. .	<u>6,725,700</u>	<u>5,452,600</u>	<u>136,800</u>	<u>1,136,300</u>

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1982 ESTIMATES

SUMMARY OF BUDGET PLANS BY INSTALLATION BY APPROPRIATION
(Millions of Dollars)

	Total			Research and Development			Construction of Facilities			Research and Program Management		
	1980	1981	1982	1980	1981	1982	1980	1981	1982	1980	1981	1982
Johnson Space Center.....	1,557.8	1,679.7	1,775.2	1,388.0	1,500.9	1,590.0	5.1	4.5	4.8	164.7	174.3	180.4
Kennedy Space Center....	461.7	506.2	559.5	300.6	349.3	376.2	27.9	4.8	20.3	133.2	152.1	163.0
Marshall Space Flight Center...	1,039.3	1,193.1	1,455.8	863.8	1,009.2	1,273.3	*19.6	*18.8	*11.3	155.9	165.1	171.2
National Space Technology Laboratories..	16.7	16.7	16.3	9.4	8.3	8.3	2.4	2.8	2.4	4.9	5.6	5.6
Goddard Space Flight Center....	688.1	729.1	935.5	551.1	581.2	778.2	3.5	4.2	5.7	133.5	143.7	151.6
Jet Propulsion Laboratory.....	319.0	282.9	416.9	315.4	276.0	403.3	3.6	6.9	13.6	---	---	---
Wallops Flight Center.....	39.0	42.3	50.5	17.5	18.5	27.9	3.8	3.4	2.2	17.7	20.4	20.4
Ames Research Center.....	257.4	226.8	274.5	147.9	137.9	174.5	42.1	15.1	22.1	67.4	73.8	17.9
Dryden Flight Research Center..	38.5	41.9	48.6	16.9	18.3	23.3	1.2	1.0	1.5	20.4	22.6	23.8
Langley Research Center.....	308.8	292.9	311.7	170.9	145.2	167.3	23.9	24.7	16.8	114.0	123.0	127.6
Lewis Research Center.....	274.1	266.9	269.9	170.7	151.8	146.3	8.6	13.7	15.6	94.8	101.4	108.0
Headquarters.....	225.4	243.6	590.8	135.9	144.2	484.0	----	---	---	89.5	99.4	106.8
Undistributed Construction of Facilities:												
Various Locations.....	.9	2.9	8.0				.9	2.9	8.0			
Space Shuttle Facilities.....	2.5	2.0	1.1				2.5	2.0	1.1			
Rehabilitation and Modification.....	---	---	.2				---	---	.2			
Minor Construction.....	---	.2	.2				---	.2	.2			
Facility Planning and Design.	14.0	10.0	11.0				14.0	10.0	11.0			
<u>Total Budget Plan.</u>	<u>5,243.2</u>	<u>5,537.2</u>	<u>6,725.7</u>	<u>4,088.1</u>	<u>4,340.8</u>	<u>5,452.6</u>	<u>159.1</u>	<u>115.0</u>	<u>136.8</u>	<u>996.0</u>	<u>1,081.4</u>	<u>1,136.3</u>

*Includes Michoud Assembly Facility..... 11.8 12.2 5.6

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1982 ESTIMATES

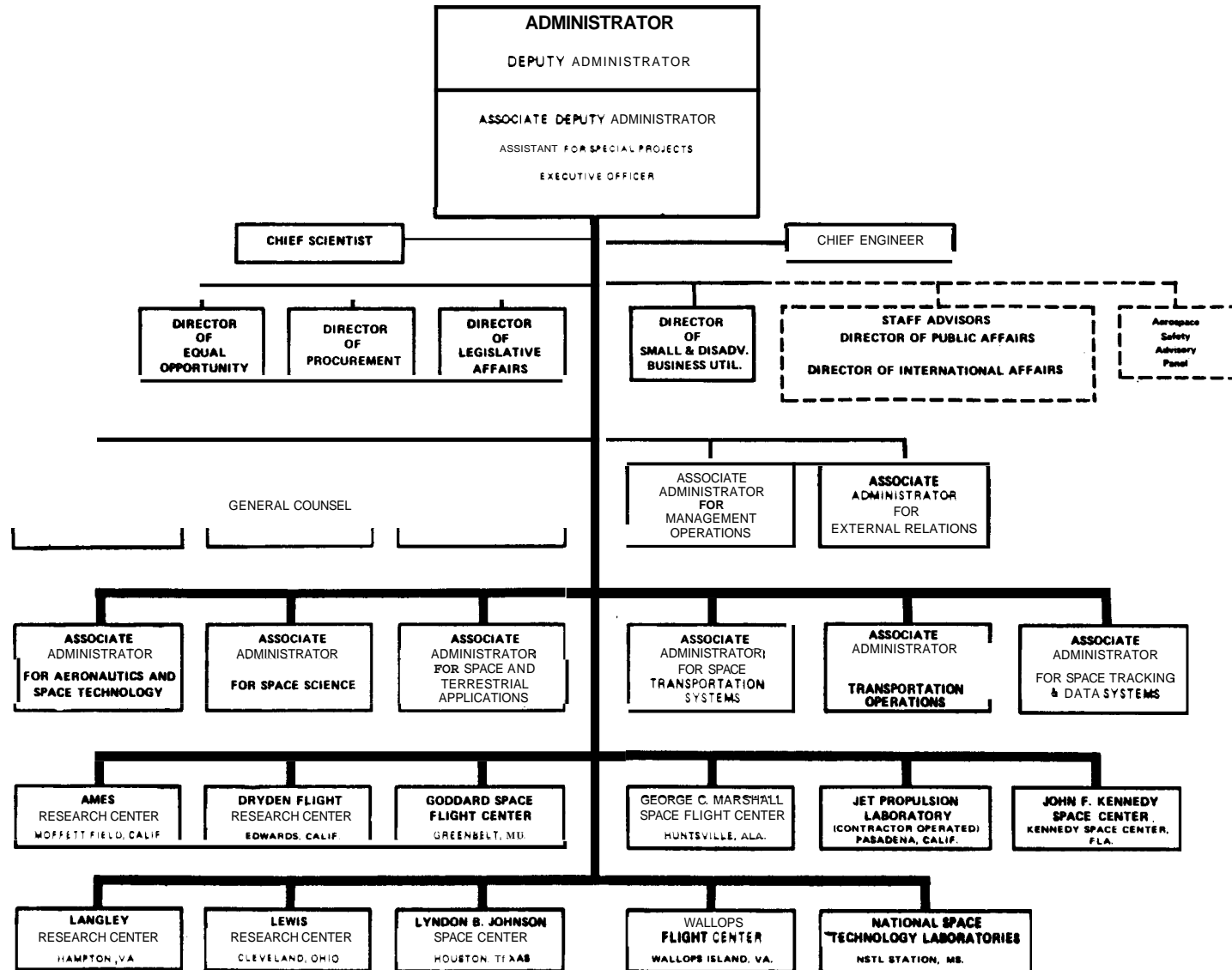
TOTAL NUMBER OF PERMANENT POSITIONS

END OF YEAR

<u>Installation</u>	<u>FY 1980</u>	<u>FY 1981</u>	<u>FY 1982</u>
Johnson Space Center	3,469	3,489	3,489
Kennedy Space Center	2,191	2,201	2,201
Marshall Space Flight Center	3,561	3,561	3,561
National Space Technology Laboratories	103	103	103
Goddard Space Flight Center	3,444	3,444	3,444
Wallops Flight Center	395	395	395
Ames Research Center	1,658	1,658	1,658
Dryden Flight Research Center	461	461	461
Langley Research Center	2,980	2,980	2,980
Lewis Research Center	2,835	2,835	2,835
Headquarters	<u>1,516</u>	<u>1,586</u>	<u>1,586</u>
Total. Permanent Positions	<u>22,613</u>	<u>22,713</u>	<u>22,713</u>

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RESEARCH AND DEVELOPMENT



RESEARCH
AND DEVELOPMENT

**SUMMARY
INFORMATION**

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1982 ESTIMATES

GENERAL STATEMENT

The objectives of the National Aeronautics and Space Administration program of research and development are to extend our knowledge of the Earth, its space environment, and the universe; to expand the practical applications of space technology; to develop, operate, and improve manned and unmanned space vehicles; to provide technology for improving the performance of aeronautical vehicles while minimizing their environmental effects and energy consumption; and to assure continued development of the aeronautics and space technology necessary to accomplish national goals. These objectives are achieved through the following elements:

SPACE TRANSPORTATION SYSTEMS: A program to provide the transportation and related capabilities required to conduct space operations. The major development objective is the reusable Space Shuttle and other elements of a versatile, economical space transportation system to provide round trip access to space and operational capabilities to meet civil and defense needs in the use of space.

SPACE SCIENCE: A program using space systems, supported by ground-based and airborne observations, to conduct a broad spectrum of scientific investigations. The objective is to advance our knowledge of the Earth and its space environment, the Sun, the planets, interplanetary and interstellar space, the other stars of our galaxy and the universe.

SPACE AND TERRESTRIAL APPLICATIONS: A program to identify, develop, and demonstrate the useful applications of space techniques in the areas of advanced communications satellite systems technology; materials processing research and experimentation; and remote sensing to acquire information which will assist in solution of Earth resources and environmental problems. To accomplish these objectives, the program employs spacecraft, airborne systems, and ground-based research and data analysis activities. The program includes activities to accelerate the dissemination to both the public and the private sectors of advances achieved in NASA's research, technology and development programs.

AERONAUTICS AND SPACE TECHNOLOGY: A program to conduct the fundamental research and to develop the technology required to maintain the United States leadership in aeronautics and space. The program also provides for identification and evaluation of elements of NASA's aeronautics and space technology which can benefit national energy programs.

TRACKING AND DATA ACQUISITION: A program utilizing a worldwide antenna network to support deep space, Earth orbital, suborbital and aeronautical activities.

SPACE TRANSPORTATION SYSTEMS

Space transportation system activities provide all of the transportation and associated support capabilities required to conduct space operations. These activities currently focus on the development and flight testing of the Space Shuttle. The Space Shuttle, the first reusable Earth-to-orbit transport vehicle, will be the key element in the space transportation system which will also include upper stages to provide high altitude orbit and planetary capabilities, and the Spacelab being developed by the European Space Agency to provide a new capability for conducting experiments in space. The space transportation system will provide the basic capability for a new era of operations in and utilization of space.

The Space Shuttle's versatility and reusability are key elements in opening a new era of expanded use of space for a wide variety of Earth applications, scientific, defense, and technological activities. The Shuttle will consist of a reusable delta-wing orbiter vehicle with three main engines, an expendable propellant tank, and reusable twin solid rocket boosters. The Shuttle will provide unique capabilities for placement and retrieval of satellites, in-orbit servicing of satellites, and delivery to Earth orbit of payloads and propulsive stages for high altitude and planetary missions. The advent of readily available, economical transportation to and from low Earth orbit for automated payloads, as well as for scientists and other personnel, will revolutionize our concepts of using space and will expand the returns from space operations. The Shuttle's unique capabilities will not only lower the cost of space operations but will also lead to savings in the costs of payloads. These anticipated savings will result from repair and reuse of payloads and relaxation of weight and size constraints. The advantages offered by the space transportation system over existing expendable launch systems will enhance both the flexibility and the productivity of space missions.

The Shuttle development program is in the final stages of certification testing for all elements with the first manned orbital flight test planned for March 1981. The tile installation on Orbiter 102, Columbia, was essentially completed in November and the orbiter was moved from the orbiter processing facility to the vehicle assembly building. The solid rocket boosters and external tank were mated on a mobile launch platform in the vehicle assembly building and were ready to receive the orbiter. The assembly and testing work in the vehicle assembly building was completed during December and the entire assembly was moved to the launch pad on December 29, 1980.

Progress in main engine testing supports the planned flight test. Approximately 100,000 seconds of ground testing have been accomplished. The significant technical problems encountered during 1980 have been corrected and the four preliminary flight certification test cycles have been completed. Additional component testing and one additional main propulsion system test are planned before the first orbital flight. All flight engines have been retested as a precaution since a number of changes have been incorporated.

The past year has been marked both by significant progress in remedying technical concerns and a comprehensive review of the program's certification status by an independent review team under the NASA Chief Engineer. The review team

pointed out certain deficiencies in testing and documentation which have been corrected. After examining the status of all program elements in July 1980, a launch readiness date of March 1981 **was** established for the first manned orbital flight. Progress during the second half of 1980 indicated a reasonable chance of meeting this schedule. **An** eighteen month orbital flight test program is planned leading to an initial operational capability in late 1982.

In the Shuttle production program Orbiter 099, used in the development phase as the structural test article, is being modified to an operational vehicle with delivery planned for mid-1982. Orbiter 103 and Orbiter 104 are being **manufactured** as new vehicles with delivery scheduled for the late 1983 and 1984 timeframe respectively. In FY 1982 efforts will begin on procurement of long lead material for a fifth orbiter. Fabrication of main engines is well underway; development and certification testing of the full power level (109% of rated power level) configured engine is planned for completion in early FY 1983.

For FY 1981, funding will be tightly constrained because requirements for design, development, test, and evaluation have increased significantly as a result of technical problems and schedule changes since development of the FY 1981 budget. The schedule changes will make it possible to reprogram \$70 million from Space Flight Operations to meet Space Shuttle requirements. Within the Space Shuttle program, it has been necessary to reallocate available funding among the various program elements.

For FY 1982, the budget for design, development, test and evaluation covers the estimated cost for completing the development and flight test program. The **FY** 1982 budget for production provides for progress on the second, third, and fourth orbiters based on the above delivery schedules and for production of main engines, for spares and equipment, and for second line ground support equipment at the Kennedy Space Center. The budget recommendation also provides a total of \$300 million for changes and systems upgrading to meet additional requirements and improvements needed as a result of actual flight experience.

The projected demand for Space Shuttle flight missions by the Department of Defense and civil sector users indicates that it would be prudent to undertake production of a fifth orbiter on a schedule that provides for a logical flow of work following the presently authorized production. The FY 1982 budget includes funding for leadtime materials and fabrication effort to preserve the option of production of a fifth orbiter to be delivered about a year and a half after the fourth orbiter.

Progress on the Space Shuttle will be **matched** in other activities vital to the establishment of the space transportation system operational capability and to preparations for early operational missions. The Spacelab, a multipurpose laboratory carried in the large cargo bay of the Space Shuttle, will allow scientists, researchers, and technicians to conduct their experiments in the unique environment of space. The Spacelab is being designed and built by the European Space Agency, with ten European nations participating in this development. Upper stages are required for use with the Shuttle for planetary missions and for Earth orbital missions such as geosynchronous missions, requiring altitudes beyond the basic Shuttle capability. A solid propellant upper stage for large **Ea**rth orbital payloads

is under development by the Department of Defense. For planetary missions, the option for use of a modified version of this stage or a modified Centaur upper stage is under review. Spinning solid upper stages are being developed and produced commercially to be used for smaller Earth orbital payloads. Development of an advanced upper stage, the Solar Electric Propulsion System, **will** be initiated in **N** 1981 and will continue in **FY** 1982. This stage will be driven by solar electric power and ionized mercury rather than conventional propellants and will meet requirements of missions needing high total impulse and long duration thrust. Other development and acquisition activities related to the Space Transportation System include ground support and control equipment, multiuse mission support equipment, and training equipment.

Space transportation system operational missions are scheduled to begin in late 1982. The **FY** 1982 budget provides for these missions through continued procurement, assembly, and checkout of the solid rocket booster, external tank and upper stages; and through flight planning, avionics software, mission integration activities, flight control systems, crew procedures, crew training, crew equipment, and other mission oriented activities.

Space transportation system activities during **FY** 1982 will also provide expendable launch vehicles and services, as well as engineering support, to meet the heavy demand for space transportation during the period of transition to the space transportation system.

SPACE SCIENCE

The space science program uses space systems supported by airborne and ground-based observations to study the Earth and its space environment, the Sun, the planets, and interplanetary and interstellar space, and the other stars of our galaxy and universe. Results from these investigations significantly contribute to our understanding of the universe, including the key questions of life, **matter**, and energy and the complex phenomena that have such a profound effect on life and environment on Earth.

The Sun exerts a primary influence on the Earth and its immediate environment. A series of orbiting solar observatory missions have been conducted to study solar phenomena. The discoveries from these missions, from the experiments flown during the Skylab program, and from the Solar Maximum Mission launched in 1980 to study the sun during the period of peak solar flare activity, are revolutionizing our understanding of the Sun. The International Solar Polar Mission, a joint NASA and European Space Agency mission, will provide information on the polar regions of the Sun--regions which cannot be observed from the Earth or from current spacecraft. To achieve the trajectories required to study these polar regions, two spacecraft will be launched by the Shuttle/upper stage, will **swing** past Jupiter, and use the gravity of that giant planet to send one spacecraft over the north pole of the Sun, and the other spacecraft **Over** the south pole. The measurements to be made are expected to yield previously unknown information about the Sun and its dynamics and to advance our understanding of the link between solar activity and weather and climate trends on Earth.

Development of the Space Telescope will continue. This multiple purpose telescope will be launched by the Shuttle, and **will** serve as a highly versatile astronomy observatory in space for **Over** a decade. The Space Telescope will greatly expand the volume of space accessible for observation, contributing significantly to our understanding of the origin and evolution of the universe and its energy-generating mechanisms.

The three High Energy Astronomy Observatory missions have been successfully launched and are yielding important scientific information. These missions explored the high energy phenomena observable with X-ray, ~~gamma~~ ray, and cosmic ray instruments. Work is also underway on explorer spacecraft to study ultraviolet and infrared astronomy and the Sun-Earth relationships, and on payloads which will capitalize on the unique capabilities of the Space Shuttle and Spacelab. The ~~Gamma~~ Ray Observatory, initiated in 1981, will take a significant next step in high energy astrophysics. This mission will conduct a comprehensive whole-sky survey in the highest energy region of the electromagnetic spectrum, which will advance knowledge of the nuclear processes occurring in the universe, and of the nature and dynamics of pulsars, galactic ~~gamma~~ ray processes, neutron stars, and black holes.

Orderly progress in the systematic exploration of the solar system is proceeding. The objectives of this effort are to understand the origin and evolution of the solar system and to better understand the Earth through comparative studies with other planets. Pioneer Venus provided basic information about the massive cloud covered atmosphere of Venus. The Voyager I spacecraft, after providing a wealth of new information about Jupiter and its four largest moons, has made spectacular contributions to our knowledge of Saturn, its rings, and its satellites. Voyager II will encounter Saturn in August 1981 and then continue on to Uranus. The Voyager results have added to our confidence that the Galileo mission to Jupiter will also be a major milestone in planetary exploration. ~~Major~~ effort in FY 1982 will be continued development on the Galileo mission which will use a probe to ~~make~~ detailed measurements of the atmosphere of Jupiter and an orbiter to conduct extensive observations of the planet and its satellites. The FY 1982 budget provides for initiation of development of the Venus Orbiting Imaging Radar mission to take a major step in acquiring scientific knowledge of the planet Venus by obtaining much more definitive data through mapping the surface of Venus than can be derived from earth-based observations and previous space missions. The scientific information obtained will directly contribute to the understanding of the Earth's evolution. The FY 1982 budget also provides for United States participation in a cooperative international program of observation of ~~Halley's~~ Comet during its appearance in 1986, and for co-investigation support on the European Space Agency Giotto mission to ~~Halley's~~ Comet.

SPACE AND TERRESTRIAL APPLICATIONS

The objective of the space applications program is to develop, demonstrate, and transfer space technology, systems and related capabilities for practical benefits here on Earth. Space applications research and development covers the areas of resource observations, environmental observations, materials processing, and communications. Technology utilization activities are designed to accelerate and expand the availability and use of technology developed in all NASA programs into the private and public sectors of the economy.

In resource observations, identification and monitoring by means of remote sensing from space have demonstrated new capabilities to provide data useful in such areas as agricultural assessments, water resources management, coastal zone monitoring, improvement of maps, land use and surface mine monitoring, forestry and range resources inventory, and mineral and petroleum exploration. Landsat-1, 2, and 3 have been providing a wide variety of data applicable in these areas. The Landsat-D spacecraft system is being developed to extend and improve remote sensing capabilities. The spacecraft is designed to carry two major remote sensing instruments, the thematic mapper and the flight-proven multispectral scanner. The thematic mapper, a second generation, high resolution instrument for remote sensing of Earth resources is well along in development. If this instrument can be completed and verified in time for a 1982 launch, it will be flown on the first Landsat-D type together with the multispectral scanner. If the thematic mapper is not ready in time, the first Landsat-D mission will be flown with the multispectral scanner only, and the thematic mapper will be flown together with the multispectral scanner on the second mission. The Magnetic Field Satellite and the Heat Capacity Mapping Mission have demonstrated the ability to provide valuable information for geophysical and geologic studies. Experiments designed to test the applicability of active microwave measurements, and of high resolution imagery for mapping investigations, are planned for flight on early Shuttle missions. Joint activities with the users continue to demonstrate specific applications of the remote sensing data in a wide variety of areas.

The joint effort in agricultural research with the Department of Agriculture, the Department of Commerce, the Department of the Interior, and the Agency for International Development will continue. This effort emphasizes the use of remotely sensed data, together with other data sources, to improve our knowledge with emphasis on improved agricultural early warning and crop commodity forecasting.

Space capabilities are also used in the development of precise measurements of the movements of the Earth's crust and other dynamic characteristics of the Earth to support research in earthquake mechanisms. A joint effort with the United States Geological Survey, National Science Foundation, National Geodetic Survey, the Department of Defense, and with other countries, will monitor the motion and internal stability of several major tectonic plates to determine the crustal deformation in seismically active areas.

The FY 1982 budget also provides for continued system definition activities in support of the National Oceanic and Atmospheric Administration responsibilities, for development and implementation of an operational Earth resources remote

sensing system, for continued definition and advanced technical development on a new solid state instrument to enhance the capability and reliability for future remote sensing of Earth resources by satellites; and for a new thrust in research and analysis activities designed to improve the effectiveness of global assessment, exploration and development of critical energy and mineral resources.

In the area of environmental observations, NASA is working with the National Oceanic and Atmospheric Administration and others in improving the understanding of atmosphere and ocean processes, providing space observations of parameters involved in these processes and extending the capabilities to predict environmental phenomena and their interaction with human activities. Areas of research and development include upper atmospheric research, global weather prediction, severe storm research, climate research, environmental quality monitoring, and oceanic processes research. This integrated approach encompasses the diverse fields of meteorology, climatology, atmospheric chemistry, atmospheric physics, and oceanography. The program focuses on the special contributions space-derived data can make in these fields.

NASA, in cooperation with other Federal agencies, is participating in a national program of climate research. Development will continue on the Earth Radiation Budget Experiment. This satellite system is designed to measure variations in the energy exchange between the Earth's atmosphere and space and other atmospheric factors important to climate research.

In addition to continuing the basic program of upper atmospheric research, the FY 1982 budget provides for mission definition and experiment design and development for an upper atmospheric research satellite mission to make integrated measurements of energy inputs, temperature, chemical constituents and winds during the next period of low sunspot activity. Work also will be in progress on atmospheric experiments to be conducted on Spacelab missions.

A National Oceanic Satellite System (NOSS) project is being initiated in FY 1981, in cooperation with the National Oceanic and Atmospheric Administration and the Department of Defense, to demonstrate an operational capability for application of remote sensing from space to oceanographic monitoring and research requirements. The National Oceanic Satellite System will be configured as a two-satellite system, launched and capable of retrieval by the Shuttle, integrated with a single preprocessing and data distribution center on the ground. Work will begin in FY 1982 on research and on scientific instruments to fully exploit the capabilities of the NOSS by utilizing the reserved capacity of the system for oceanic and atmospheric research.

Materials processing research and development activities are designed to exploit the unique characteristics of the space environment to achieve results which are not possible or practical on Earth. Experiments are being conducted in laboratories and with sounding rockets to build on the results of tests conducted on previous space flights and to prepare for experiments to be conducted on future Spacelab missions. The FY 1982 program provides for continued development of equipment and related activities for experiments to be conducted on early Spacelab missions and for enhancement of research activities.

Communications research and development efforts concentrate on advanced technology for communications satellite systems with significantly improved capabilities and on providing technical support and consultation to other government agencies. Development is proceeding on the search and rescue locator system, a cooperative venture with other United States agencies, Canada, and France, to demonstrate improved capabilities for detecting and locating distress signals from aircraft and marine vessels. The FY 1982 program also provides continuation of advanced communications research activities, and definition studies and advanced technology development on an experimental wideband communications satellite to operate the recently allocated 30/20 GHz spectrum bands.

Technology utilization activities are designed to accelerate the transfer of new knowledge and innovative technology generated by NASA and NASA contractors to the nonaerospace industry, as well as to State and local governments. During FY 1982, NASA will continue its efforts to assure effective and widespread dissemination of new technology through a variety of established mechanisms including publications, industrial applications centers, a computer software management and information center, State technology applications centers, special application teams, and applications engineering projects.

IC: RESEARCH AND OGY

The objective of the aeronautics program is to provide the technology base essential for continued United States leadership in aeronautics. This technology base is needed for the development of future aircraft with improved performance, fuel efficiency, safety, and environmental acceptability. The technology base also underlies the strong competitive position of the United States in the world aviation marketplace and the continued superiority of the Nation's military aircraft. The recommended program for FY 1982 includes a strong research and technology base effort; continuation of ongoing systems technology activities, extension of efforts relating to improved fuel efficient long-range transports, advanced rotorcraft, general aviation safety, and a significant initiative in development of a new numerical computational capability for fluid dynamics.

The FY 1982 budget includes the necessary activities to provide a strong research and technology base. These activities place emphasis on the technology disciplines of aerodynamics, propulsion, avionics and flight controls, human-vehicle interaction, materials and structures; and on the conduct of focused technology activities relevant to the major classes of aeronautical vehicles such as conventional take-off and landing aircraft, rotorcraft and high performance aircraft.

The FY 1982 budget provides for initiation of development of the Numerical Aerodynamic Simulator, a major new and unique capability in the field of computational fluid dynamics. Development of this national resource will promote United States leadership in large-scale computer technology, provide a quantum improvement in analytical capability for advancing aeronautical sciences, and have a major impact on development of advanced aircraft.

Progress will continue in the aircraft energy efficiency systems technology that can lead to a major reduction in fuel requirements for transport aircraft. In addition to efforts now in progress, the recommended FY 1982 program includes follow-on program phases in composite aircraft structures to develop the technology required to validate the structural durability of major critical transport wing and fuselage subcomponents.

The budget also provides for continuing focused systems technology efforts to develop verified design methods, design criteria and systems concepts for future quiet, efficient, and all weather rotorcraft.

Critical resources technology effort will be undertaken to help reduce the dependence of United States aviation on foreign suppliers by identifying new high temperature alloys with potential to reduce the use of materials, such as cobalt, columbium, chromium, and tantalum which are used in hot section components of gas turbine engines, and by investigating the effects of the use of lower grades of fuel, including shale oil and coal sources, for aircraft propulsion.

Other examples of focused technology efforts include core design and higher temperature technology applicable to variable cycle propulsion systems, technology for increasing the efficiency, and reducing the noise and weight of propellers for general aviation aircraft, and high performance flight experiments conducted in cooperation with the Department of Defense to investigate advanced aerodynamic, structural, and propulsion concepts applicable to future military aircraft.

SPACE RESEARCH AND TECHNOLOGY

The objectives of the space research and technology program are to provide a technology base which will adequately support current and future space activities and to implement approaches for further reducing the costs of future space activities through improvement of components. The FY 1982 budget applies increased resources to fundamental disciplinary research and technology. This increase is a much needed step toward reestablishing emphasis on the longer term aspects of space technology which are critical to future United States leadership in space. Research and technology base activities include the following major areas:

- Aerothermodynamics involving re-entry heating and control with emphasis on advanced technology for aerobraking and aerocapture and on aerodynamics of advanced transportation systems.
- Chemical propulsion covering advanced orbital transfer vehicle propulsion, planetary retropropulsion, and low-thrust propulsion, providing an increased emphasis on oxygen-hydrogen Earth-to-orbit propulsion.
- **Materials and** structures with increasing emphasis on technology for assembly, construction, and deployment of structures in space.

- Electronics and automation including increased emphasis on autonomy in launch, test, and checkout; command and control; spacecraft self-management teleoperator technology; smart sensors; and control of attitude and shape of large structures.
- Power and electric propulsion including high quality space power systems, thermoelectric power conversion, and advanced power and electric propulsion concepts.
- Information systems emphasizing technology for advanced sensor systems and data management, analysis, and distribution.
- Spacecraft systems with emphasis on large space systems and future spacecraft concepts including thermal management and contamination control technology.
- Transportation systems activities defining new concepts for advanced transportation systems as well as conducting flight experiments using the Space Shuttle.

Systems technology activities involve shorter-term technology activities including antenna experiments and other technology relevant to a 30/20 GHz communication satellite, solar cell and array experiments, and other experiments to be conducted on Spacelab missions.

ENERGY TECHNOLOGY

Energy technology efforts in NASA are primarily directed toward identifying the technology developed in the aeronautics and space program which has potential for making major contributions to the solution of energy problems on Earth. NASA provides technical support to the programs undertaken by other agencies to develop specific applications such as solar cells, solar heating and cooling, and electric power generation by wind power. NASA also makes its capabilities and facilities available to the Department of Energy and other agencies to accomplish energy technology activities on a reimbursable basis.

TRACKING AND DATA ACQUISITION

This program provides the vital tracking and data support required by all NASA flight projects in accomplishing their mission objectives. This support is provided by a worldwide network of NASA electronic ground stations and transportable laser tracking facilities interconnected by a communications system using ground, undersea, and satellite circuits. Computation facilities also are provided to process into usable form the large amounts of scientific, applications, and engineering data which are collected from flight projects. In addition, instrumentation facilities are provided for support of sounding rocket launchings and flight testing of aeronautical research aircraft.

In FY 1982, operations funding will provide support to some fifty individual spacecraft missions and to Space Shuttle orbital flight tests. Systems funding will sustain the existing facilities and systems at the lowest levels consistent with the support of the ongoing missions and provide the necessary modifications to meet the requirements of approved future flight missions including those of the operational space transportation system. The FY 1982 budget also provides effort on the planned consolidation of the spaceflight tracking and data network and deep space network into a single network.

A major aspect of the tracking and data acquisition program in future years will be the Tracking and Data Relay Satellite System (TDRSS), which will support essentially all Earth orbital spacecraft missions and will greatly improve NASA's Earth orbital tracking and data acquisition capabilities. NASA will acquire this capability through an arrangement under which the contractor will establish the system and provide NASA with TDRSS services beginning in FY 1983.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROPOSED APPROPRIATION LANGUAGE

Federal Funds

General and special funds:

RESEARCH AND DEVELOPMENT

For **necessary** expenses, not otherwise provided for, including ~~re-~~search, development, operations, ~~services~~, minor construction main*
nance, repair, rehabilitation and modification of real and personal
property, tracking and data relay satellite ~~services~~ as authorized by
law; purchase, ~~hire~~, maintenance, and operation of other than admin-
istrative aircraft, **necessary** for the conduct and support ~~of~~ aeronauti-
~~cal~~ and space research and development activities of the National
Aeronautics and Space Administration [; and including not to exceed
(1) \$29,000,000 for Space Transportation Systems Upper Stages, (2)
\$30,900,000 for Space Transportation System Operation—Upper
Stages, (3) \$119,300,000 for the Space Telescope, (4) \$39,600,000 for the
International Solar Polar Mission, (5) \$19,100,000 for the Gamma Ray
Observatory, (6) \$63,100,000 for Project Galileo, (7) \$88,500,000 for
Landsat D, (8) \$1,873,000,000 for the Space Shuttle, and (9)
\$149,700,000 for Spacelab, without the approval of the Committees on
Appropriations, \$4,896,200,000,] **\$5,452,600,000**, to remain available
until September 30, [1982.] 1983. (42 U.S.C. 2451, et seq.; Department
of Housing and Urban Development—Independent Agencies Appropri-
ation Act, 1981; additional authorizing legislation to be proposed.)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RESEARCH AND DEVELOPMENT

Program and Financing (in thousands of dollars)

Identification code 80-0108-0-1-999	Budget plan (amounts for research and development actions programmed)			Costs and obligations		
	1980 actual	1981 at.	1982 at.	1980 actual	1981 at.	1982 at.
Program by activities:						
Direct program:						
1. Space transportation systems:						
(a) Space shuttle	1,871,000	1,943,000	2,230,000	1,802,740	2,010,500	2,100,600
(b) Space flight operations	446,600	683,700	1,043,000	426,377	569,800	978,400
(c) Expendable launch vehicle development	21,100	38,500	22,900	36,362	49,150	32,300
2. Scientific investigations in space:						
(a) Physics and astronomy	349,100	350,200	456,400	338,063	334,000	416,800
(b) Planetary exploration	219,900	175,600	256,100	193,343	194,500	257,000
(c) Life sciences	43,800	42,188	49,200	41,547	44,000	38,500
3. Space and terrestrial applications:						
(a) Space applications	365,620	363,950	476,200	335,864	368,450	429,150
(b) Technology utilization	11,980	111,800	14,600	10,499	13,100	11,800
4. Space research and technology	115,586	110,700	141,000	111,350	110,800	125,900
5. Aeronautical research and technology	308,300	276,150	323,600	262,895	272,000	291,650
6. Energy technology	3,000	3,900	4,400	4,889	2,900	4,200
7. Supporting activity:						
(a) Tracking and data acquisition	332,100	341,100	435,200	314,592	323,800	417,100
Total direct program	4,088,086	4,340,788	5,452,600	3,878,521	4,293,000	5,103,400
Reimbursable program:						
1. Space transportation systems:						
(a) Space shuttle	75,162	82,230	97,000	27,825	75,730	100,420
(b) Space flight operations	53,834	59,604	143,000	83,744	64,150	136,560
2. Scientific investigations in space:						
(a) Physics and astronomy	1,235	1,387	1,700	868	1,500	1,750
(b) Planetary exploration	78	88	100	5	80	100
(c) Life sciences	133	149	200	246	170	200
3. Space and terrestrial applications:						
(a) Space applications	270,217	291,422	431,000	156,270	282,030	432,560
(b) Technology utilization	14,607	10,762	12,000	13,497	16,260	12,530
4. Space research and technology	1,325	415	400	1,561	1,070	430
5. Aeronautical research and technology	22,060	17,583	17,600	17,108	20,770	18,710
6. Energy technology	210,765	218,600	338,000	165,642	221,020	337,400
7. Supporting activity:						
(a) Tracking and data acquisition	7,205	7,760	9,000	5,751	7,220	9,340
Total reimbursable program	656,621	690,000	1,050,000	472,517	690,000	1,050,000
Total program costs, funded	4,744,707	5,030,788	6,502,600	4,351,038	4,983,000	6,153,400
Change in selected resources (undelivered orders and stores)				140,292	634,991	349,200
10.00 Total	4,744,707	5,030,788	6,502,600	4,491,330	5,617,991	6,502,600

Program and Financing (in thousands of dollars)—Continued

Modification code 80-0108-0-1-999		Budget plan (amounts for research and development actions programmed)			Costs and obligations		
		1980 actual	1981 est.	1982 est.	1980 actual	1981 est.	1982 est.
Financing:							
Offsetting collections from:							
11.00	Federal funds.....	- 463,132	- 465,803	- 766,980	- 408,022	- 465,803	- 766,980
14.00	Non-Federal sources.....	- 193,489	- 224,197	- 283,020	- 157,813	- 224,197	- 283,020
Unobligated balance available, start of year: For completion of prior year budget plans:							
21.40	Direct.....				- 239,006	- 368,724	
21.40	Reimbursable.....				- 185,885	- 218,479	
Unobligated balance available, end of year: For completion of prior year budget plans:							
24.40	Direct.....				368,724		
24.40	Reimbursable.....				218,479		
25.00	Unobligated balance lapsing.....				719		
39.00	Budget authority.....	4,088,086	4,340,788	5,452,600	4,088,086	4,340,788	5,452,600
Budget Authority:							
40.00	Appropriation.....	4,092,500	4,396,200	5,452,600	4,092,500	4,396,200	5,452,600
40.00	Reduction pursuant to Public Law 96.....		- 55,412			- 55,412	
40.01	Appropriation rescinded (Public Law 96-304).....	- 1,414			- 1,414		
41.00	Transferred to other accounts.....	- 3,000			- 3,000		
43.00							
Appropriation (adjusted)		4,088,086	4,340,788	5,452,600	4,088,086	4,340,788	5,452,600
Relation of obligations to outlays:							
71.00	Obligations incurred, net.....				3,925,495	4,927,991	5,452,600
72.40	Obligated balance, start of year.....				- 785,812	1,008,505	1,882,296
74.40	Obligated balance, end of year.....				- 1,088,363	- 1,882,296	- 2,261,496
77.00	Adjustments in expired accounts.....				- 1,350		
90.00	Outlays.....				3,701,452	4,054,200	5,073,400

* Includes capital investment as follows: 1980 \$46,773 thousand; 1981 \$118,598 thousand; 1982 \$138,638 thousand.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1982 ESTIMATES

BUDGET PLAN SUMMARY

		<u>FY 1980</u>	<u>FY 1981</u>	<u>FY 1982</u>
		(Thousands of Dollars)		
<u>Code</u>	<u>SPACE TRANSPORTATION</u>	<u>2,385,000</u>	<u>2,681,100</u>	<u>3,304,200</u>
253	Space Shuttle.....	1,871,000	1,943,000	2,230,000
253	Space flight operations.....	446,600	683,700	1,043,000
253	Expendable launch vehicles.....	67,400	54,400	31,200
	<u>SPACE SCIENCE</u>	<u>600,500</u>	<u>562,488</u>	<u>756,700</u>
254	Physics and astronomy.....	336,800	344,700	451,400
254	Planetary exploration	219,900	175,600	256,100
254	Life sciences.....	43,800	42,188	49,200
	<u>SPACE AND TERRESTRIAL APPLICATIONS</u>	<u>343,600</u>	<u>365,350</u>	<u>487,500</u>
254	Space applications.....	331,620	353,550	472,900
254	Technology utilization	11,980	11,800	14,600
	<u>AERONAUTICS AND SPACE TECHNOLOGY</u>	<u>426,886</u>	<u>390,750</u>	<u>469,000</u>
402	Aeronautical research and technology.....	308,300	276,150	323,600
254	Space research and technology.....	115,586	110,700	141,000
254	Energy technology.....	3,000	3,900	4,400
255	<u>TRACKING AND DATA ACQUISITION</u>	<u>332,100</u>	<u>341,100</u>	<u>435,200</u>
	Total.....	<u>4,088,086</u>	<u>4,340,788</u>	<u>5,452,600</u>

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1982 ESTIMATES

SUMMARY OF BUDGET PLAN BY SUBFUNCTION

<u>Code</u>		<u>FY 1980</u>	<u>FY 1981</u>	<u>FY 1982</u>
		(Thousands of Dollars)		
253	Space Flight.. ..	2,385,000	2,681,100	3,304,200
254	Space Science, Applications and Technology.. ..	1,062,686	1,042,438	1,389,600
255	Supporting Space Activities.....	<u>332,100</u>	<u>341,100</u>	<u>435,200</u>
(250)	Subtotal, General Science, Space and Technology.. ..	3,779,786	4,064,638	5,129,000
402	Air Transportation.....	<u>308,300</u>	<u>276,150</u>	<u>323,600</u>
	<u>Total.....</u>	<u>4,088,086</u>	<u>4,340,788</u>	<u>5,452,600</u>

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
FISCAL YEAR 1982 ESTIMATES

(Thousands of Dollars)

PROGRAM	TOTAL	Johnson Space Center	Kennedy Space Center	Marshall Space Flight Center	National Space Technology Laboratories	Goddard Space Flight Center	Jet Propulsion Laboratory	Wallops Flight Center	Ames Research Center	Dryden Flight Research Center	Langley Research Center	Lewis Research Center	NASA Headquarter
OFFICE OF SPACE TRANSPORTATION													
SYSTEMS, TOTAL.....	1980 2,385,000	1,327,126	296,333	669,480	6,050	43,693	395	---	85	900	5,595	17,000	18,343
	1981 2,681,100	1,429,700	343,300	819,600	5,000	51,200	---	---	---	1,300	1,700	5,500	23,800
	1982 3,304,200	1,505,700	370,700	1,052,900	5,300	32,000	---	---	---	1,600	900	---	336,100
Space Shuttle.....	1980 1,871,000	1,183,665	205,032	469,668	250	50	340	---	85	900	495	---	11,515
	1981 1,943,000	1,254,900	239,300	432,400	---	---	---	---	---	1,300	800	---	14,300
	1982 2,230,000	1,268,400	256,800	389,800	---	---	---	---	---	1,600	100	---	313,300
Space flight operations.....	1980 446,600	143,461	86,601	200,812	5,800	5,143	55	---	---	---	---	---	4,728
	1981 683,700	174,800	102,400	387,200	5,000	5,500	---	---	---	---	---	---	8,800
	1982 1,043,000	237,300	112,200	663,100	5,300	3,800	---	---	---	---	---	---	21,300
Expendable launch vehicles....	1980 67,400	---	4,700	---	---	38,500	---	---	---	---	5,100	17,000	2,100
	1981 54,400	---	1,600	---	---	45,700	---	---	---	---	900	5,500	700
	1982 31,200	---	1,700	---	---	28,200	---	---	---	---	800	---	500
OFFICE OF SPACE SCIENCE													
TOTAL.....	1980 600,500	24,184	3,628	154,308	---	83,952	192,623	5,816	70,814	108	722	---	64,345
	1981 562,488	23,745	5,679	158,466	---	87,478	154,015	7,613	54,979	555	37	---	69,921
	1982 28,959	5,037	176,072	---	---	160,039	230,348	9,372	57,768	615	13	---	88,477
Physics and astronomy.....	1980 336,800	146	2,796	154,186	---	79,637	51,027	5,816	14,673	---	675	---	27,844
	1981 344,700	1,680	4,877	158,331	---	83,687	48,616	7,613	12,714	---	37	---	27,145
	1982 451,400	4,594	3,503	175,872	---	155,454	55,701	9,372	8,913	---	13	---	37,978
Planetary exploration.....	1980 219,900	7,495	---	122	---	4,290	139,321	---	40,049	---	7	---	28,616
	1981 175,600	8,259	---	135	---	3,756	104,276	---	26,894	---	---	---	32,280
	1982 256,100	8,984	---	200	---	4,546	173,402	---	30,279	---	---	---	38,689
Life sciences.....	1980 43,800	16,543	832	---	---	25	2,275	---	16,092	108	40	---	7,885
	1981 42,188	13,806	802	---	---	35	1,123	---	15,371	555	---	---	10,496
	1982 49,200	15,381	1,534	---	---	39	1,245	---	18,576	615	---	---	11,810
OFFICE OF SPACE AND TERRESTRIAL APPLICATIONS, TOTAL ...	1980 343,600	25,626	587	28,852	3,330	182,547	27,260	4,490	17,429	55	17,078	12,707	23,639
	1981 365,350	38,603	210	21,920	3,210	196,260	24,330	4,310	18,837	37	13,410	19,964	24,259
	1982 467,500	44,925	320	30,160	2,925	279,415	42,240	6,415	13,785	50	19,215	19,330	28,720
Space applications.....	1980 331,620	25,616	508	28,460	3,190	181,788	24,999	4,119	16,560	---	16,378	11,897	18,105
	1981 353,550	38,503	110	21,420	3,060	195,310	22,630	4,190	17,937	---	12,410	19,464	18,516
	1982 472,900	44,775	170	29,620	2,750	278,135	40,250	6,040	12,535	---	18,325	18,580	21,720
Technology utilization.....	1980 11,980	10	79	392	140	759	2,261	371	869	55	700	810	5,534
	1981 11,800	100	100	500	150	950	1,700	120	900	37	1,000	500	5,743
	1982 14,600	150	150	540	175	1,280	1,990	375	1,250	50	890	750	7,000
OFFICE OF SPACE TECHNOLOGY, TOTAL ...	1980 426,886	11,032	20	10,640	---	9,436	24,777	625	59,558	12,834	147,507	140,967	9,490
	1981 390,750	8,825	80	9,005	50	9,000	22,015	600	64,100	13,400	130,100	126,300	7,275
	1982 469,000	10,425	120	13,950	100	12,400	27,680	800	103,000	17,500	147,200	127,000	8,825
Aeronautical research and technology	1980 308,300	745	---	725	---	---	780	625	50,590	12,834	120,096	117,756	4,149
	1981 276,150	200	---	700	---	---	800	600	54,300	13,300	101,400	100,600	4,250
	1982 323,600	100	---	800	---	---	1,000	800	91,000	17,400	111,000	97,000	4,500
Space research and technology	1980 115,586	10,287	---	8,920	---	9,436	23,071	---	8,968	---	27,411	22,228	5,265
	1981 110,700	8,400	---	7,000	---	9,000	19,700	---	9,800	100	28,700	25,000	3,000
	1982 141,000	10,100	---	11,700	---	12,400	24,900	---	12,000	100	36,200	29,700	3,900
Energy technology	1980 3,000	---	20	995	---	---	926	---	---	---	---	983	76
	1981 3,900	225	80	1,305	50	---	1,515	---	---	---	---	700	25
	1982 4,400	225	120	1,450	100	---	1,780	---	---	---	---	300	425
OFFICE OF SPACE TRACKING AND DATA SYSTEMS	1980 332,100	---	---	555	---	231,460	70,375	6,580	---	3,050	---	---	20,080
	1981 341,100	---	---	200	---	237,300	75,600	5,950	---	3,050	---	---	19,000
	1982 435,200	---	---	200	---	294,300	103,000	11,300	---	3,500	---	---	22,900
TOTAL BUDGET PLAN	1980 4,088,086	1,387,968	300,568	863,835	9,380	551,088	315,430	17,511	147,886	16,947	170,902	170,674	135,897
	1981 4,340,788	1,500,873	349,269	1,009,191	8,260	581,238	275,960	18,473	137,916	18,342	115,247	151,764	144,255
	1982 5,452,600	1,590,009	376,177	1,273,282	8,325	778,154	403,268	27,887	114,553	23,265	167,328	146,330	484,022

SUM 17

SPACE
TRANSPORTATION
PROGRAMS I

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1982 ESTIMATES

RESEARCH AND DEVELOPMENT BUDGET PLAN FOR SPACE TRANSPORTATION SYSTEMS

<u>Programs</u>	Budget Plan			
	<u>1980 Actual</u>	<u>1981</u>		<u>1982 Budget Estimate</u>
		<u>Budget Estimate</u> (Thousands of Dollars)	<u>Current Estimate</u>	
Space Shuttle.....	1,871,000	1,886,000	1,943,000	2,230,000
Space flight operations.....	446,600	446,600	683,700	1,043,000
Expendable launch vehicles.....	<u>67,400</u>	<u>70,700</u>	<u>54,400</u>	<u>31,200</u>
<u>Total.....</u>	<u>2,385,000</u>	<u>2,403,300</u>	<u>2,681,100</u>	<u>3,304,200</u>

SPACE
SHUTTLE

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1982 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE TRANSPORTATION SYSTEMS

SPACE SHUTTLE PROGRAM

	BUDGET SUMMARY		BUDGET SUMMARY		Page No. _____
	1980 Actual	1981 Budget Estimate (Thousands of Dollars)	1981 Current Estimate	1982 Budget Estimate	
<u>Design. Development. Test Evaluation</u>	<u>1,115. 500</u>	<u>683. 000</u>	<u>958. 000</u>	<u>740. 000</u>	
Orbiter	641. 900	320. 900	521. 000	372. 000	RD 1-7
Main engine	140. 606	145. 700	134. 000	127. 000	RD 1-10
External tank	79. 400	48. 000	54. 500	25. 000	RD 1-12
Solid rocket booster	65. 200	14. 000	44. 500	17. 000	RD 1-14
Launch and landing	188. 400	154. 400	204. 000	199. 000	RD 1-15
<u>Changes/Systems Upgrading</u>	<u>---</u>	<u>150. 000</u>	<u>---</u>	<u>300. 000</u>	RD 1-18
<u>Production</u>	<u>755. 500</u>	<u>1,040. 000</u>	<u>985. 000</u>	<u>1,190. 000</u>	
Orbiter	572. 600	768. 200	727. 500	873. 000	RD 1-20
Main engine	123. 600	121. 500	121. 500	105. 000	RD 1-22
Launch and landing	16. 400	40. 400	34. 000	57. 000	RD 1-23
Spares and equipment	42. 900	109. 900	102. 000	155. 000	RD 1-25
Total	<u>1,871. 000</u>	<u>1,873. 000</u>	<u>1,943. 000</u>	<u>2,230. 000</u>	

	1980 <u>Actual</u>	1981 <u>Budget</u> <u>Current</u> <u>Estimate</u> <u>Estimate</u> (Thousands of Dollars)		1982 <u>Budget</u> <u>Estimate</u>
<u>Distribution of Program Amount by Installation:</u>				
Johnson Space Center.....	1,183,665	1,104,200	1,254,900	1,268,400
Kennedy Space Center.....	205,032	196,900	239,300	256,800
Marshall Space Flight Center.. ..	468,668	408,300	432,400	389,800
National Space Technology Laboratories	250	5,500	---	---
Goddard Space Flight Center.. ..	50	---	---	---
Jet Propulsion Laboratory.....	340	---	---	---
Ames Research Center.....	85	---	---	---
Dryden Flight Research Center.....	900	700	1,300	1,600
Langley Research Center.	495	---	800	100
Redates	<u>11,515</u>	<u>157,400*</u>	<u>14,300</u>	<u>313,300*</u>
Total.....	<u>1,871,000</u>	<u>1,873,000</u>	<u>1,943,000</u>	<u>2,230,000</u>

*Includes changes/systems upgrading estimates

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1982 ESTIMATES

OFFICE OF SPACE TRANSPORTATION SYS

SPACE SHUTTLE PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The Space Shuttle is the key element of a versatile, economical space transportation system that will provide a wide variety of national and international users with round trip access to space beginning in the 1980's. The Space Shuttle will be the first reusable space vehicle, and will be configured to carry many different types of payloads to and from low Earth orbit. Its development will provide multipurpose, economical space operations for Earth applications, scientific, defense, and technological payloads. The Space Shuttle is, however, much more than just a transportation vehicle. It will offer unique capabilities that cannot be achieved with today's expendable launch vehicles -- to retrieve payloads from orbit for reuse; to service and repair satellites in space; to transport to orbit, operate, and return space laboratories; to transport materials and equipments to orbit; and to perform rescue missions. These capabilities will greatly enhance flexibility and productivity, and result in savings in the cost of space operations.

The Space Shuttle consists of four basic flight hardware elements -- the orbiter, the main engines, an expendable external propellant tank (ET), and twin solid rocket boosters (SRB) -- plus launch and landing systems. The orbiter is the reusable spacecraft portion of the Space Shuttle. Its large payload volume of 285 cubic meters (370 cubic yards) and cargo carrying capacity of up to 29,500 kilograms (65,000 pounds) will permit payloads to be built to less restrictive design requirements. The orbiter vehicle will carry personnel and payloads into orbit to perform their assigned tasks and return them to Earth. The orbiter is roughly the size of a DC-9 aircraft and contains three liquid fueled reusable main engines. It will also provide a habitable environment for the crew, which will include scientists and engineers.

MISSION PROFILE:

The Space Shuttle will be launched into space by the thrust of its three liquid oxygen/liquid hydrogen main engines, burning in parallel with the twin solid rocket boosters. Two minutes into the flight, at an altitude of about 45 kilometers (km) (24 nautical miles), the solid rocket boosters will burn out, separate, and descend by parachute to a soft splashdown in the ocean about 260 km (140 nautical miles) downrange. They will then be recovered for refurbishment and reuse. The three main engines will continue to burn for another six and one-half minutes. Just before orbital insertion, the engines will be shut down and the external tank will be jettisoned. Following a ballistic trajectory,

the empty tank will reenter, tumble, and break up over a remote ocean area about 18,500 km (10,000 nautical miles) downrange. The orbiter, aided by its orbital maneuvering engines, will enter Earth orbit to perform its mission. After completing the mission, the orbiter will again fire its orbital maneuvering engines to deorbit and reenter the atmosphere for its approach and landing.

The Space Shuttle will have a crew of three: the commander, the pilot, and the mission specialist. On some missions, up to four more mission or payload specialists may be added. The crew will experience forces not greater than three times that of gravity (3-g forces) during launch and landing, and will be able to perform their work in a shirt-sleeve environment.

STATUS:

The Space Shuttle program is in the final period of development toward the first orbital flight (STS-1), expected in March of 1981, with all flight elements integrated into the space vehicle which is now in prelaunch processing at the Kennedy Space Center (KSC). The technical problems which delayed our earlier planned launch (i.e., thermal protection system installation and testing, and hardware certification and verification) have been resolved. Orbiter 102 (Columbia), which will be used for the orbital flight test (OFT) program, rolled out of the orbiter processing facility (OPF) on November 24, 1980, to the vehicle assembly building (VAB) where it was mated with the external tank (ET) and the two solid rocket boosters (SRB) on December 2, 1980. Following integrated testing of these elements they were moved to the launch pad on December 29, 1980, for final launch preparation. Other STS-1 activities such as hardware certification and avionics verification are also proceeding and are near completion.

FY 1980 main engine activities included single engine and mated engine testing, and the preliminary flight certification program in preparation for the first orbital flight. The technical problems occurring in 1980 (a fuel preburner burn-through, a main injector post failure, and a failure of an orifice in a thrust control sensing port) have been corrected. In addition to the problem resolution activities, the four preliminary flight certification (PFC) cycles required prior to the first flight were completed with two engines. In total, they accumulated Over 52 tests and more than 20,000 seconds of operation. Three of these PFC cycles were at the 100% rated power level (RPL) and the last cycle was at 102% of RPL. In addition, the three engines to be used for the first orbital flight were modified, re-acceptance tested, and in November 1980 reinstalled in Orbiter 102. The main engine program has accumulated over 600 tests and 95,000 seconds of operation, including about 1,100 seconds at 109% of RPL. The main propulsion test (MPT) series is continuing at NSIL to demonstrate the 109% power level.

The first flight external tank (ET) is at KSC where mating with the SRB's and orbiter have been completed. The second external tank (ET-2) is in final checkout for delivery in April 1981. The remainder of the tanks for the orbital flight test program, along with the first four tanks (including the first lightweight tank) for the operations phase of the program, are in various stages of manufacture at the Michoud Assembly Facility.

The final solid rocket motor qualification test firing occurred in February 1980. This completed a series of four development firings and three qualification firings. Subsystem component qualification tests were completed to support the STS-1 flight. Propellant casting for STS-2 and six of the eight segments for STS-3 have been completed.

At KSC significant progress has been made in preparing the various Space Shuttle elements, facilities and ground support equipment to support the launch of STS-1. Although the major effort in the orbiter processing facility (OPF) has been tile installation and completion of orbiter manufacturing, numerous subsystem tests have been completed and major orbiter integrated system tests have been conducted. The launch processing system (LPS) is operational and is supporting vehicle and facility checkout. Software for the orbiter, SRB, ET, and facility subsystem checkout and operation is available and being utilized. Vehicle system procedures and software to be used in final Space Shuttle on-pad checkout and launch are being developed and validated. Launch pad cryogenic, hypergol, and other fluid, mechanical, and electrical systems are in final checkout to support Space Shuttle processing. The contractor and civil service workforce at KSC are on an around-the-clock schedule in order to achieve the planned launch date for the first flight. After STS-1, KSC will be involved in the retrieval and disassembly of the SRB's, deservicing of the orbiter, and vehicle processing for STS-2.

Orbiter 099 (Challenger), used in the development phase as the structural test article (STA), is being modified to an operational vehicle, with delivery planned for mid-1982. Orbiter 103 and Orbiter 104 are being manufactured as new vehicles with delivery scheduled for the late 1983 and 1984 timeframes respectively. Efforts which will extend into FY 1982 are underway to develop improved materials for the thermal protection system, to provide for follow-on procurement of the remote manipulator system, and to initiate procurement of long lead time material for a fifth orbiter.

Fabrication and assembly of engines for installation into Orbiter 099 will be completed in FY 1981. These engines will then be acceptance tested and delivered to KSC during FY 1982. Fabrication and assembly of engines for installation into follow-on orbiters are underway and will be delivered in 1983 and 1984. Fabrication of engines for Orbiter 103 will be completed in FY 1982.

Launch and landing production phase activities include purchasing ground support equipment and modifying facilities in order to support two to three orbiter vehicles in simultaneous processing. This includes a second high bay in the orbiter processing facility, a second set of high bays in the vehicle assembly building, a second mobile launch platform, a second launch pad, and a solid rocket motor processing facility.

Spares and equipment funds provide for the initial operational inventory of crew equipment, necessary spares for flight hardware and ground support equipment, plus ET and SRB production rate tooling. This includes orbiter flight spares, orbiter and launch site ground support equipment spares, the extravehicular mobility units (each comprised of a space suit assembly, a primary life support system, and a portable oxygen system), main engine spares, and ET and SRB production tooling to support the operation flight rate buildup.

CHANGES FROM FY 1981 ESTIMATE:

The total Space Shuttle estimate for FY 1981 has increased by \$70 million, which is to be reprogrammed from Space Flight Operations (STS Operations). These funds can be made available because of reductions in requirements resulting from the delay in the first operational flight. In addition, funding estimates within the Space Shuttle program have been adjusted consistent with increased development (DDT&E) requirements. The DDT&E requirements have increased substantially primarily due to technical problems encountered in development, certification and launch preparation activities and the resultant delay of STS-1 and extension of the orbital flight test (OFT) program. As a result, it has been necessary to allocate the funding budgeted under changes and system upgrading to meet added requirements and changes in the DDT&E effort. In addition, \$55 million of funds budgeted for production are reallocated to meet the DDT&E requirements. These funds are available as a result of rephasing of production activities. Detailed explanations are contained in the applicable sections that follow.

MAJOR PROGRAM ACTIVITIES PLANNED IN FY 1982:

- e Complete orbital flight test missions
- e Continue main propulsion testing to demonstrate 109% of rated power performance
- e Complete the second set of flight main engines
- e Complete delivery of the fourth solid rocket booster flight set hardware for the OFT program
- e Complete delivery of the external tanks for the OFT program
- e Analyze OFT flight data for application to operational flights
- Continue follow-on orbiter fabrication and assembly leading to a national fleet of operational orbiters
- Reconfigure Columbia for the first operational flight
- e Complete first qualification firing of the performance improved solid rocket booster
- Complete refurbishment of the STS-1 solid rocket boosters

DESIGN, DEVELOPMENT, TEST, AND EVALUATION

	1980 <u>Actual</u>	<u>1981</u>		1982 <u>Budget Estimate</u>
		<u>Budget Estimate</u> (Thousands of Dollars)	<u>Current Estimate</u>	
Orbiter.....	641,900	320,900	521,000	372,000

OBJECTIVES AND STATUS:

The Space Shuttle orbiter is a reusable vehicle which serves as the orbiting spacecraft to deploy and retrieve payloads in low Earth orbit and provides living quarters for personnel in orbit. The orbiter reenters the atmosphere and lands as an unpowered aircraft, returning crew and payloads. A payload of up to 29,500 kilograms (65,000 pounds) can be placed in low Earth orbit at an altitude of 185 kilometers (100 nautical miles). The physical dimensions of the payload may be as large as 4.6 meters (15 feet) in diameter and 18.3 meters (60 feet) in length. The Orbiter Columbia (OV 102) ~~was~~ assembled in Palmdale, California, and delivered to the orbiter processing facility (OPF) at the Kennedy Space Center (KSC) in March 1979. Planned thermal protection system (TPS) installations, OPF testing, and hardware modifications were completed and the orbiter ~~was~~ rolled out of the OPF to the vehicle assembly building (VAB) on November 24, 1980. The orbiter ~~was~~ mated with the external tank (ET) and the solid rocket boosters (SRB's); and, following integrated testing with these elements, the stacked vehicle ~~was~~ moved to the launch pad on December 29, 1980, for final launch preparations.

Other orbiter STS-1 related activities have also continued. Hardware certification is nearly complete with most of the certification testing finished. Avionics verification testing is proceeding and is also nearly complete.

Substantial effort during the past year has been devoted to the thermal protection system. In addition to completing the tile installations on Orbiter 102, detailed analysis of the tile installations were conducted to determine structural margins, and each tile ~~was~~ proof tested to 1.25 times the expected flight loads. Concurrently, the TPS certification test program ~~has~~ continued to demonstrate mission life capability under conditions simulating acoustic, structural, and thermal loads. Testing to assess damage effects and failure modes were conducted, as well as off-limit testing to determine actual thermal margins. Special tests were initiated to confirm design changes, and several tests were added to investigate further areas of concern, such as aerodynamic shock during the transonic phase of the ascent trajectory. All TPS certification testing for STS-1 will be completed in early 1981.

The phased development of flight software for the primary and backup systems has been planned to provide early deliveries of the software to support avionics verification in the Space Shuttle avionics integration laboratory (SAIL) at JSC and the flight systems laboratory (FSL) at Rockwell in Downey, California. Verification testing is grouped into three categories: Category 1 - Basic: test cases for both nominal and off-nominal conditions for all phases of the flight regime; Category 2 - Regression: test cases to validate changes to the original baseline system (hardware and software); Category 3 - Mission Unique: test cases designed to validate the unique trajectory and flight conditions of the mission.

The basic verification testing for nominal and off-nominal conditions has been completed; the regression and mission unique testing is scheduled to be completed in early February 1981. Upon completion of the STS-1 verification activities, the laboratories (SAIL and FSL) will be reconfigured to support STS-2 and subsequent flights. The STS-1 final flight software has been delivered. The software for STS-2 through STS-4 is scheduled for delivery in August 1981.

Testing of the various communication links with the rest of the avionics system, utilizing the SAIL and the electrical systems test laboratory (ESTL) has also been performed. Combined system testing of the flight control actuation systems for the aerosurfaces and the main engine thrust vector controls with the Space Shuttle hydraulic systems, using the FSL hardware evaluator and flight control hydraulics, has also been completed.

The generation of data and documentation for integrating the remote manipulator system (RMS) with the orbiter and for on-orbit flight testing of the DDT&E unit produced by Canada is near completion. An RMS configuration review has been held, and it has been determined that the Canadian design will meet NASA performance requirements. Canadian DDT&E activities were focused upon final testing and necessary improvements to the flight hardware, and continued RMS flight performance simulations with astronaut participation. The RMS flight hardware is scheduled to be delivered in early 1981.

CHANGES FROM THE FY 1981 BUDGET ESTIMATE:

The N 1981 orbiter estimate has increased by \$200.1 million. The increase was caused by technical problems which delayed the scheduled rollout of Orbiter 102 from the orbiter processing facility (OPF) and led to the delay in the OFT program and the initial operational capability date. Manufacturing manpower levels had to be sustained through the first two months of FY 1981 in order to complete bonding of the TPS and installation of hardware modifications. Higher engineering manpower levels have been required due to delays in the completion of certification work. System and subsystem change activity has had an impact on subcontractor costs.

Increases in requirements have also been experienced in the support areas caused by schedule extensions and additional testing requirements for systems integration and Johnson Space Center (JSC) program support efforts. In SAIL the

extension of the Shuttle test station to a third shift plus maintenance for a full year, and the guidance, navigation and control test station to a second shift for a full year is required to maintain the avionics verification activity. Increases in the IBM effort to implement software changes consistent with the resolution of hardware anomalies, plus new requirements have been added to the software baseline. The requirements in the on-orbit TPS inspection and repair activity have been increased to accelerate the availability date for the hardware. Additional shifts have also been added for simulator training to support the orbital flight test (OFT) program. In April 1980, a fire in the extravehicular mobility unit (EMU) primary oxygen system occurred. This resulted in an extensive investigation of the cause of the fire, and a redesign of the faulty system. The EMU program was also impacted by the addition of two extra space suit sizes, bringing the total from three to five sizes required.

BASIS OF FY 1982 ESTIMATE:

The OFT program using Orbiter 102 is planned to begin in the March of 1981 with the first manned orbital flight of STS-1, and will continue through FY 1982. Major activities in FY 1982, therefore, will be the conducting of the remaining OFT flights and the post flight data analysis. Each development flight is a test to support progressively the verification of the Space Shuttle for operational use, to verify hardware and software operation, ground and flight procedures, system characteristics over a range of conditions, primary and backup operational modes, and overall performance. Flight test data on the systems performance will be reviewed after each flight and corrective action taken, where necessary, to meet operational requirements. Throughout the development flight test program, engineering support will be provided to perform this analysis, resolve problems, and verify systems operations. The FY 1982 efforts will lead to the certification of the Space Shuttle's readiness to enter the operational phase. Engineering support required for the OFT program will be the major activity during FY 1982. Remaining OFT certification testing and analysis and life cycle testing will also be completed.

The completion of TPS ground testing and accumulation of repetitive tests to validate design mission life will take place. It is planned to demonstrate a 400 equivalent mission capability to certify the TPS for the planned 100 operational missions. Considerable effort in FY 1982 will be devoted to analysis of thermal data gathered during flight testing, allowing refinement of actual margin determination and trajectory envelope capability.

In FY 1982 the SAIL and FSL will be used to provide near real-time mission support. They will also be used to analyze flight data, prepare analysis for post-flight reports, and to investigate flight anomalies. Specific avionics verification programs will be conducted for each OFT mission to confirm the avionics operation with primary and backup flight software in the new configurations. These include operations of the RMS, KU-band radar, and the tracking and data relay satellite (TDRS). Flight support and post-flight analysis will be conducted for each subsequent orbital test

flight. Testing and analysis of some specific mission operations involving vehicle maneuvering and extravehicular activity will be conducted in the SAIL and FSL to verify the avionics system support of the mission plans. Avionics equipment and flight software improvements will be incorporated during the OFT program and early operational flights. The software deliveries are phased to be commensurate with avionics improvements and mission requirements. Each of these improvements will also be verified on SAIL and FSL.

MAJOR PROGRAM ACTIVITIES PLANNED IN FY 1982:

- Conduct remaining OFT flights
- Continue support to OFT flights with engineering, data analysis, anomaly resolution, and incorporation of necessary changes
- Delivery mission/mod kits for OFT flights
- Complete Orbiter 102 hardware certification and operational life testing

	1980	1981		1982
	<u>Actual</u>	Budget <u>Estimate</u>	Current <u>Estimate</u>	Budget <u>Estimate</u>
		(Thousands of Dollars)		
Main engine.	140,600	145,700	134,000	127,000

OBJECTIVES AND STATUS:

The Space Shuttle orbiter will use three high pressure liquid hydrogen/oxygen engines, each with a 2,100,000 newton (470,000 - pound) vacuum thrust level. The Space Shuttle main engine (SSME) represents a major advance in propulsion technology, and incorporates maximum utilization of existing technologies. In addition, it has the advantage of a long operating life. It is the first large liquid fuel rocket engine designed to be reusable, and will require minimum maintenance between flights. An engine-mounted controller is used to ensure operation within the limits of the high temperatures and pressures in the combustion cycle. Performance has been increased by using a two-stage combustion process with a high expansion ratio nozzle which results in more efficient engine operations.

In 1980 several engine problems were discovered. On July 12, 1980, a main propulsion test was prematurely terminated because of a hot gas burn-through in a fuel preburner wall. On July 23, 1980, after 47 tests and 14,210 seconds of operation on one engine, including about 1,100 seconds at 109% of rated power level (RPL), several main injector LOX posts failed. On July 30, 1980, an orifice in a thrust control sensing port failed resulting in significant damage to some parts of the engine. To preclude future fuel preburner burn-throughs and orifice failures, modifications were designed, developed, and tested. By November 1980, these modifications were incorporated in the three engines of the first manned orbital flight vehicle (OV-102). Design changes to increase main injector LOX post life from 14,000 seconds to Over 7.5 hours are being incorporated in the second set of flight engines along with all other full power level (FPL) engines.

Beyond resolving the technical problems encountered during 1980, significant progress **was** also realized in the preliminary flight certification (PFC) program. Completion of this effort **was** required prior to **STS-1**. It consisted of four cycles with each cycle requiring a minimum of thirteen specific tests with a total accumulation of 5,000 seconds of engine operation. Using two engines (units 2004 and 0009), this effort **was** completed on December 2, 1980. Three cycles were conducted at 100% of rated power level (RPL), and each cycle included one full duration test (520 seconds) at 102%. The fourth cycle **was** at 102% of rated power level. This last cycle also included one test at 104%. Together, engines 2004 and 0009 through the four PFC cycles have accumulated over 52 tests and 20,000 seconds of operation.

After completing the second PFC, engine 2004 **was** subjected to test at 109% of RPL. It successfully completed a demonstration program consisting of three mission cycles each simulating abort condition requirements at 109%. About 1,100 seconds at this thrust level were accumulated. Subsequently, during further testing at 102%, engine 2004 experienced the main injector LOX post failures described earlier. To that point, engine 2004 had accumulated 47 tests and 14,200 seconds of operation.

Through November 1980, the main engine program had accumulated a total of over 660 tests and more than 95,000 seconds of operation (including MPT). Included in the FY 1980 effort **was** the reacceptance testing of the first flight set, engines 2005, 2006, and 2007.

In FY 1981, continuing support will be provided for the orbital flight tests (OFT). This will include a full complement of component and full engine test capability and analytical support for the flights. In addition to this effort, development of the full power level (FPL - 109% of RPL) configured engine (units 2008 and subsequent) will constitute the major thrust of the development activity.

In addition to the development and test work by Rocketdyne and subcontractors, the main engine activities provide the necessary project support efforts. These include engineering, the procurement of propellants, the maintenance of the engine systems hardware simulation laboratory, logistics support, and the evaluation of materials and processes.

CHANGES FROM FY 1981 BUDGET ESTIMATE:

The FY 1981 estimate for the main engine has been reduced by \$11.7 million, primarily due to the decision to modify only one of the three main propulsion test engines to conduct the full power level (109%) MPT test program. The other two MPT-FPL engines will be production engines.

BASIS OF FY 1982 ESTIMATE:

During FY 1982, a full complement of support capability will be provided for the OFT. Single engine development testing of the FPL engine will continue. It is expected that this development effort will demonstrate sufficient engine

maturity that FPL certification testing can be initiated during FY 1982. Two main propulsion tests are also scheduled in early FY 1982 to demonstrate FPL operation of three engines in a cluster. FY 1982 main engine funding will also support the engine system simulation laboratory, engine software integration, and procurement of propellants for the Santa Susana and NSIL test site activities.

MAJOR PROJECT ACTIVITIES PLANNED IN FY 1982:

- Continue engine testing to achieve final flight certification at FPL
- Complete MPT - full power level testing
- Provide laboratory, test, and analytical support for the OFT program

	1980	1981		1982
	<u>Actual</u>	<u>Budget</u> <u>Estimate</u>	<u>Current</u> <u>Estimate</u>	<u>Budget</u> <u>Estimate</u>
		(Thousands of Dollars)		
External tank.....	79,400	48,000	54,500	25,000

OBJECTIVES AND STATUS:

The external tank (ET) will contain all the propellants for the orbiter's three main engines - liquid hydrogen as the fuel and liquid oxygen as the oxidizer. The liquid propellants are consumed by the orbiter's main engines from liftoff to main engine cutoff, which occurs just before orbital insertion. Following the main engine cutoff, the ET will separate from the orbiter and fall through a ballistic trajectory to break up over a designated remote ocean area. The ET is a single assembly approximately 8.5 meters (27.5 feet) in diameter and 47 meters (154 feet) long. It will contain approximately 700,000 kilograms (1.55 million pounds) of propellant at liftoff. The liquid hydrogen volume is 1,530 cubic meters (54,000 cubic feet) and the liquid oxygen volume is approximately 565 cubic meters (20,000 cubic feet).

During 1980, mating of the first flight tank (ET-1) with the ~~SB's~~ and the orbiter for STS-1 was completed. Final preparations are now being made for the scheduled launch in March of 1981. The lightweight tank critical design review (CDR) was completed in November 1980, and manufacturing of the first lightweight tank has begun.

The second flight tank (ET-2) is in final checkout. Delivery of this tank to KSC is planned for April 1981. The third and fourth flight tanks will be structurally assembled, the thermal protection system applied, and readied for shipment to KSC during 1981 and 1982.

During FY 1981, a major engineering effort will be expended on the lightweight tank (LWT) design and manufacturing. The **goal** of reducing the weight of the tank by 6,000 pounds will be achieved by optimizing the thickness of the basic skin, ribs, and chords of the intertank, and the liquid oxygen and liquid hydrogen tanks.

In N 1981, efforts are also being undertaken to improve the producibility of the ET. The basic objective is to develop new techniques and processes to build the ET more efficiently and more economically. **Areas** of activity include improved welding techniques and an automated inspection system, an alternate foam material for the liquid hydrogen tank aft dome, and improvements in tank priming, cleaning and protection.

CHANGES FROM FY 1981 BUDGET ESTIMATE:

The ET estimate for FY 1981 has increased by \$6.5 million. This increase **was** caused principally by growth in the efforts to **prevent** icing on protuberances, and the extension of the development hardware activities to support the building of ET-2, ET-3, and ET-4, consistent with the delay in the STS-1 flight schedule and the extension of the orbital flight test program.

BASIS OF FY 1982 ESTIMATE:

The fourth development tank will be in the final phases of assembly and checkout at the NASA Michoud Assembly Facility with delivery planned for the first half of FY 1982. Producibility improvements in assembly and manufacturing techniques will be continued during the year in order to reduce operational costs. LWT design activity will be completed in N 1982, while flight support activities will continue throughout the year.

MAJOR PROJECT ACTIVITIES PLANNED IN FY 1982:

- o Deliver last development external tank (ET-4)
- Complete final ET installation at KSC for STS-3 and STS-4
- Continue designs for producibility improvements
- Provide engineering support to the OFT program

	1980	1981		1982
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of Dollars)		
Solid rocket booster.....	65,200	14,000	44,500	17,000

OBJECTIVES AND STATUS:

The Space Shuttle propulsion system includes two reusable solid rocket boosters which burn in parallel with the orbiter main engines at launch to provide the necessary thrust from liftoff to booster staging. Each solid rocket booster weighs approximately 583,600 kilograms (1.29 million pounds) and delivers approximately 11.6 million newtons (2.6 million pounds) average vacuum thrust. The solid rocket boosters are approximately 3.6 meters (12.2 feet) in diameter, 45.5 meters (149 feet) long, and are attached to the external tank. After burnout, at an altitude of about 45 kilometers (150,000 feet), the boosters separate from the external tank. The solid rocket boosters will descend by parachute and land in the ocean about 260 kilometers (140 nautical miles) from the launch site. They will be recovered by ship and returned for refurbishment and reuse.

The main element in the solid rocket booster system is the solid rocket motor (SRM), which is being developed by Thiokol, Wasatch Division, in Utah. Other booster system elements such as the recovery system, thrust vector control (TVC), attach structures, forward and aft skirt, and separation motors are being procured separately. MSFC has the responsibility for total systems integration of the solid rocket booster effort.

In 1980 the final qualification motor was successfully static test fired. This completed the DDT&E series of four development and three qualification firings. Subsystem component qualification tests were completed to support the STS-1 flight. The booster assembly contractor has been actively involved with the assembly and checkout of the booster for STS-1.

All major ground tests for the SRB subsystems have also been successfully completed. These included overall TVC systems tests, SRB/ET separation tests, parachute drop tests, full-scale structural testing, and electrical and instrumentation systems testing. Propellant casting of the STS-3 flight motor segments, and the assembly of the STS-3 subsystems were also started during 1980. Solid rocket motor lightweight case components, which will increase the payload capability of the Space Shuttle by approximately 600 pounds, have been hydro-tested to confirm the structural integrity and seal capability of the clevis joints. The components have also been subjected to a burst test to obtain biaxial stress and strain data.

CHANGES FROM FY 1981 BUDGET ESTIMATE:

The SRB estimate for FY 1981 has increased by \$30.5 million. This increase was caused primarily by the inclusion of an SRM performance improvement program to provide for approximately 3,000 pounds of additional payload, as well as DDT&E flight hardware delivery delays necessary to support the slipped development flight schedule.

BASIS OF FY 1982 ESTIMATE:

The assembly of flight hardware for STS-2 and STS-3 will continue through 1981. The booster assembly contractor will also be involved with the refurbishment and checkout of recovered hardware from the STS-1 mission.

During FY 1982, the SRB contractors will continue with the assembly and checkout of the SRB's for the final two DDT&E flights. Also, refurbishment and checkout of two flight sets of recovered hardware for reuse will be completed.

To provide for additional payload capability of approximately 3,000 pounds, the solid rocket motor performance enhancement program will continue through FY 1982. The first improved operational motor is scheduled for launch in 1983. FY 1982 activities will include the continuation of design, fabrication, and testing of two qualification motors. To improve producibility, new techniques and processes to build SRB components more efficiently will be undertaken.

MAJOR PROJECT ACTIVITIES PLANNED FOR FY 1982:

- Complete assembly and checkout of flight SRB's at KSC for the OFT program
- Complete qualification motor firings of the improved performance solid rocket motor
- Complete refurbishment of the first two OFT flight boosters
- Provide engineering support to OFT program

	1980 <u>Actual</u>	1981		1982 <u>Budget Estimate</u>
		<u>Budget Estimate</u> (Thousands of Dollars)	<u>Current Estimate</u>	
Launch and landing.....	188,400	154,400	204,000	199,000

OBJECTIVES AND STATUS:

The Space Shuttle launch and landing project includes the preparation of a series of Space Shuttle landing, ground processing, launch processing, and launch station sets at the Kennedy Space Center (KSC) and landing systems at the Dryden Flight Research Center (DFRC) and their operation through the OFT phases. These station sets include handling systems, testing systems, servicing systems, and ground support equipment (GSE). The launch control center (LCC) at KSC contains the heart of the computerized automated launch processing system (LPS), which connects to many of the station sets for remote monitoring and control of the vehicle testing, servicing, checkout and launch processing. In addition to the landing facilities at KSC and DFRC, landing support facilities are planned for construction at the White Sands Missile Range, New Mexico, to provide a backup landing site for early OFT flights.

Activation of the various launch and landing station sets **has** been paced to match the flight hardware development, certification, and readiness for flight. During FY 1980 the launch support team **was** implemented at the level required to support orbiter checkout in the orbiter processing facility (OPF) and to support final activation and checkout of facilities needed for the first Shuttle flight. The Space Shuttle landing stations at DFRC and KSC and the OPF and LPS at KSC were activated in FY 1979, and were operational at the beginning of FY 1980. The mobile launcher, parachute packing facility, propulsive element checkout area (for SRB, ET, SSME), and vehicle assembly stations in the VAB were activated in the first quarter of FY 1980. A second firing room and LPS control set were activated in FY 1980 to allow the development and checkout of ground test software in parallel with vehicle testing. During FY 1980 facilities were constructed at White Sands in order to handle the orbiter processing in event of landings at that site.

Delivery and installation of the required KSC STS-1 GSE **was** completed during FY 1980. GSE spares have been provisioned, processing fluids have been supplied to support checkout and testing, and initial propellants and flight systems replacement spares are being accumulated for the first launch. At the pad, the fuel cell and hypergolic propellant loading systems have been through the test certification phase and an ice protection and purge swing arm **has** been installed. The remaining GSE is being implemented on schedule.

The major portion of launch and landing efforts involve the operation of the station sets and the processing and launch of the flight hardware. The development contractors which provide on-site launch support include Rockwell International, Martin-Marietta, United Space Boosters, Inc., and Thiokol.

The orbiter Columbia **was** in processing in the OPF from its delivery to KSC in March 1979 until its rollout to the VAB on November 24, 1980. Columbia **was** delivered to the VAB with a minimum of incomplete flight systems and TPS tile installations and has since been undergoing manufacturing completion in parallel with systems testing. Most systems have now been tested. Over 90% of all required qualification and certification tests have been performed. Final pre-launch performance and integration tests are the primary effort remaining to be completed. The first flight ET **was** delivered in July 1979. Delivery of the first set of flight SRB hardware **was** completed during November and December 1979. The ET, SRBs, and orbiter Columbia are now mated on the mobile launcher at the launch pad. The Shuttle interface test (SIT) **has** been completed, and preparations are underway for the flight readiness firing, countdown and launch.

In late FY 1980, NASA confirmed the decision to maintain the commitment for a first Space Shuttle launch in March 1981 despite the delay in the OPF rollout schedule. This decision **was** announced following an intensive program review. One key element of the decision **was** to adopt a four-month work schedule utilizing a seven-day, three-shift operation for those activities necessary from OPF rollout to launch. This work schedule has resulted in increased manpower requirements for processing the vehicle for launch. From rollout on November 24, 1980, to the March 1981 launch date, many employees involved with critical path work processing will be required to work high levels of overtime and additional personnel are required beyond those projected in the FY 1981 budget estimate to support the planned activities.

After launch, the orbiter will land at DFRC, be deserviced, then mated with the carrier aircraft and ferried back to KSC; there it will be inspected, repaired, and reprocessed including any necessary replacement of TPS tiles. The SRBs will be retrieved and disassembled for refurbishment and reprocessing. Other flight elements will be processed for STS-2 during N 1981, and work on the turnaround of Columbia will be completed. The second Shuttle launch is scheduled for the fourth quarter of FY 1981.

CHANGES FROM FY 1981 BUDGET ESTIMATE:

The launch and landing estimate **has** increased \$49.6 million, primarily to support the compressed effort required to process the Shuttle vehicle for launch. The compressed effort **has** increased the development and support contractor funding requirements substantially. Work is being scheduled seven days, three shifts, rather than five days, two shifts, as projected in the FY 1981 budget estimate.

BASIS OF FY 1982 ESTIMATE:

During FY 1982, the principal activities in the launch and landing project will focus on processing flight elements to complete the OFT program. The fiscal year effort will include intensive activities supporting vehicle processing in the OPF, VAB, and at the launch pad to test, checkout and launch STS-3, STS-4, and the first operational flight (STS-5). The processing activity is supported by LPS operations, logistics, transportation, propellants, and spares provisioning. There are also provisions for facility and equipment modifications and required changes through this development period.

MAJOR PROJECT ACTIVITIES PLANNED IN FY 1982:

- Perform element and space vehicle processing and launch for STS-3, 4, and 5
- Retrieve and refurbish reusable flight hardware from OFT flights
- Prepare for the transition to the operational mode

CHANGES AND SYSTEMS UPGRADING

	<u>1980 Actual</u>	<u>1981</u> <u>Budget</u> <u>Estimate</u> (Thousands of Dollars)	<u>Current</u> <u>Estimate</u>	<u>1982</u> <u>Budget</u> <u>Estimate</u>
Changes and systems upgrading	---	150,000	---	300,000

OBJECTIVES AND STATUS:

Management, technical, and cost reviews of the Space Shuttle program have stressed the imperative need for providing an adequate allowance for changes and modifications which inevitably are required in a large, complex, and technically demanding space system.

The changes and systems upgrading budget represents the estimated requirement for potential changes and systems modifications and unanticipated developments which are not included in the budget estimates for development and production. Such funds are necessary to provide an adequate allowance for programmatic and technical changes which result from Space Shuttle development ground and flight testing, and experience in the production phase. Those changes include modification to the orbiters to improve flight performance and system reliability, changes and upgrading of ground systems to reduce turnaround time between missions, and replacement/modification of hardware elements to achieve increased operating economies.

As the changes and upgrading requirements are identified and approved, funds will be allocated to DDT&E or production accordingly .

CHANGES FROM FY 1981 BUDGET ESTIMATES:

The changes and systems upgrading funds identified in the FY 1981 budget have been reallocated to Shuttle DDT&E to help offset the cost of changes and increased development requirements associated primarily with the delay in STS-1 launch schedule and the extended orbital flight test program. Other increased development requirements include the acceleration of the on-orbit TPS inspection and repair capability, and resolution of certification testing problems in the space suit and life support systems development.

BASIS FOR FY 1982 ESTIMATE:

The funding requested for FY 1982 represents the estimated flexibility required to accomplish the anticipated modifications which are likely to result from the initial flight tests and the potential changes to increase reliability and operating efficiency. Changes and upgrading efforts include modifications to flight and ground systems; design and development of hardware/software systems which meet requirements for improved safety, reliability, performance and cost-effectiveness; and changes to flight and ground systems which will reduce operational costs by extending their operational life, facilitating improved mission-to-mission turnaround timelines, and achieving improved mission performance margins. The estimate assumes a generally nominal orbital flight test program, out of which requirements would arise for relatively minor ground and flight system modifications and improvements. Such changes and system upgrading might include tandem elevator actuators to improve reliability; a redesigned rudder/speedbrake powerdrive unit; auxiliary power unit and fuel cell improvements; minor modifications to the main engines; and ground system improvements such as additional launch processing system checkout, control, and monitor subsystem hardware.

PRODUCTION

	1980 <u>Actual</u>	1981 <u>Budget Estimate</u> <u>Current Estimate</u> (Thousands of Dollars)		1982 <u>Budget Estimate</u>
Orbiter.....	572,600	768,200	727,500	873,000

OBJECTIVES AND STATUS:

The Space Shuttle production program is based on a national fleet of vehicles currently approved as four orbiters, plus the maintenance of an option for a fifth orbiter. Three additional orbiter vehicles are now being procured in the production phase. Orbiter 099, used in DDT&E as the structural test article, is being modified to an operational vehicle while Orbiter 103 and Orbiter 104 are being manufactured as new vehicles. Orbiter 102, the DDT&E vehicle, will also be modified to an operational configuration after completion of the orbital flight test program. During the past year the majority of effort **has** been placed on subcontractor procurements for Orbiter 099. In FY 1981, the effort will be shared between Orbiter 099 and Orbiter 103 requirements.

The Orbiter 099 airframe has been demated, test instrumentation has been removed, and major structural elements returned to their respective contractors where they are well along in rework. The main structure consisting of the mid and lower fuselage and wings is in rework at the Rockwell (RI) facility in Palmdale, California. A new crew module for Orbiter 099 is being fabricated at the RI facility in Downey, California, and will be delivered to Palmdale for mating with the lower forward fuselage in mid-1981. Secondary structures installation is proceeding, and TPS installations were begun in September 1980.

Orbiter 103 long-lead procurements and detail parts manufacturing are underway at this time. Subcontractor fabrication and assembly of major structural elements, including the wings, elevons, and mid fuselage, are underway. Orbiter 103 weight saver design engineering is also in process. Long-lead procurements for Orbiter 104 have been initiated. Long-lead titanium material procurements for Orbiter 105 are planned to be initiated.

With the signing of the follow-on production contract in FY 1980 for three production remote manipulator system (RMS) units, the Canadian procurement and manufacturing activities have increased. The first production RMS flight system is scheduled for delivery during the third quarter of FY 1982. The second and third flight units will begin manufacture in late N 1981 and begin assembly in late N 1982.

CHANGES FROM FY 1981 BUDGET ESTIMATE:

The FY 1981 current estimate has been reduced by \$40.7 million. This reduction is due to several changes in the phasing of planned production activities- This includes the delay in the planned increase in systems integration efforts due to the continuing requirements in development and compatibility verification of the Vandenberg Air Force Base (VAFB) facilities; the deferral of global positioning systems (GPS) effort; deletion of the procurement of eight manned maneuvering units (MMU); deferral of design reviews and system verification activities for Orbiter 099. The funding has been reallocated to the Space Shuttle DDT&E program to help offset increased requirements resulting from the extended orbital flight test program and the delay in the first operational flight.

BASIS FOR FY 1982 ESTIMATE:

Delivery of Orbiter 099 is scheduled in mid-1982, Orbiter 103 in late 1983, and Orbiter 104 in late 1984. During FY 1982, Orbiter 099 will be in the final assembly period at Palmdale. Final systems installations, mating, and TPS installations will take place. Final checkout will be conducted and the vehicle will be delivered to KSC via the 747 carrier aircraft.

For Orbiter 103, the major effort in FY 1982 will be delivery and installation of major structural elements and primary and secondary structures, the continuation of initial systems installations, and the initiation of TPS installations. During FY 1982, detail parts manufacturing for Orbiter 104 will continue and structural assembly will be initiated.

An intensive program is also underway, which will continue into FY 1982, to develop improved materials for thermal protection systems on subsequent orbiters and for retrofit on Orbiter 102. Four areas of improvement which currently are being studied are: addition of silicon carbide pigment to the basic silica tile, replacement of the low temperature (white) tiles with a silica blanket, substitution of fiber reinforced ceramic (FRCI) tiles for the higher temperature (black) tiles, and incorporation of an improved strain isolator pad (SIP).

Activity in production support areas will also continue in FY 1982. The authority to proceed on additional closed circuit television (CCTV) equipment for production orbiters will be given later in 1981. Activity in FY 1982 for the CCTV will be the manufacture and delivery of the first production unit. Procurement of follow-on RMS flight units from Canada will continue in FY 1982, and the first follow-on unit will be delivered in mid-1982. The major effort in FY 1982 for the automatic checkout equipment (ACE) will be the initiation and completion of checkout of Orbiter 099 at Palmdale prior to delivery. Software development for later flights will continue in FY 1982 and will include changes resulting from OFT and other operational mission unique payloads. The initial phase of the acquisition and first use of the

software production facility (SPF) will take place in FY 1982. The SPF is required to support the operational software requirements and will produce a flight software package for each operational flight. The SPF acquisition is planned for completion in N 1986.

Long-lead component and subsystem procurements and purchase of titanium material will be made during FY 1982 to maintain the option for a fifth orbiter vehicle if continuing studies indicate the need for an additional orbiter.

MAJOR PROGRAM ACTIVITIES PLANNED FOR FY 1982:

- Complete assembly, test, checkout, and delivery of Orbiter 099
- Continue manufacture of Orbiter 103
 - delivery of major structural elements
 - installation of primary and secondary parts
 - continuation of initial systems installation
 - installation of TPS
- Continue detail part manufacturing and initiate assembly of major structural elements for Orbiter 104
- Development of improved TPS for operational vehicles
- Procurement of follow-on RMS units
- Procurement of long-lead material for a fifth orbiter
- Delivery of CCTV equipment for Orbiter 099
- Begin software production facility acquisition and use

	1980	1981		1982
	<u>Actual</u>	Budget <u>Estimate</u>	Current <u>Estimate</u>	Budget <u>Estimate</u>
		(Thousands of Dollars)		
Main engine.....	123,600	121,500	121,500	105,000

OBJECTIVE AND STATUS:

The Space Shuttle main engine (SSME) design and development effort through FY 1980 has progressed in expanding the SSME operating envelope from the FMOF configuration engine (100% RPL) to the full power level (FPL) engine (109% RPL). The production budget provides the material procurement, fabrication and assembly operation necessary to support the orbiter fleet with FPL engines. The first production (FPL configuration) engine was assembled in late FY 1980. From materials procurement to final main engine assembly covers a time span of about 42 months. Then another few months are required for shipping to NSTL, test stand installation, acceptance testing, final checkouts and inspections before

delivery to KSC. In FY 1982, the materials procurement, fabrication and assembly operations necessary to support the orbiter production and flight schedule will continue. Current analyses indicate that to meet these Shuttle program requirements through 1985, a production flow of about one completed engine every four months is near optimal.

BASIS OF FY 1982 ESTIMATE:

FY 1982 funds are required to continue the fabrication and assembly of FPL configuration flight engines. Component deliveries such as main injector, turbopumps, main combustion chamber parts, etc., will be phased to support the fabrication and assembly operations. Fabrication and assembly of engines for installation into Orbiter 103 will be completed and the engines for installation into Orbiter 099 will be acceptance tested during FY 1982. The fabrication of components for the completion of engines for subsequent Orbiters will be phased throughout FY 1982 to meet the assembly requirements and planned delivery dates in succeeding fiscal years. After assembly, each engine is transported to NSTL for acceptance testing. This effort requires logistics, evaluation and analysis support.

JOB PROJECT ACTIVITIES I IN FY 1982:

- Assemble engines to outfit Orbiter 103
- Acceptance test flight engines for Orbiter 099

	1980	1981		1982
	<u>Actual</u>	<u>Budget</u> <u>Estimate</u>	<u>Current</u> <u>Estimate</u>	<u>Budget</u> <u>Estimate</u>
		(Thousands of Dollars)		
Launch and landing.....	16,400	40,400	34,000	57,000

OBJECTIVES AND STATUS:

The first line of facilities at KSC supports the launch processing and checkout of one orbiter vehicle through launch and landing. When the second orbiter vehicle is delivered there must be additional ground and launch support equipment installed as "second line facilities" to allow processing of two to three orbiters simultaneously. Included in the second line facilities is a second high bay in the OPF, a second set of high bays in the VAB, a second mobile launch platform (MLP), a second launch pad, and a solid rocket motor processing facility. Procurements are being initiated on long-lead items of ground support equipment (GSE), some requiring as much as two years lead time. System engineering effort is required to ensure the orderly activation of facilities and implementation of changes to specifications, drawings, and documentation that have occurred during first line activation efforts.

CHANGES FROM FY 1981 BUDGET ESTIMATE:

The FY 1981 current estimate has been reduced by \$6.4 million by deferring the operational readiness date for OPF-2 by approximately six months, consistent with the extension of the OFT program and the delay of three months in STS initial operational capability.

BASIS OF FY 1982 ESTIMATE:

The thrust of the FY 1982 effort will be to design, install, check out, and validate the second line of GSE and facilities in support of orbiter deliveries.

The installation contract on the second OPF high bay and all GSE procurement deliveries will be completed during FY 1982. Effort will then be directed toward final hookup, checkout, and validation to support prelaunch orbiter processing no later than September 1, 1982.

Construction of the basic second mobile launcher platform was completed in 1979. Numerous design modifications required on the first MLP will be incorporated on MLP-2. The installation contract will be completed during the year as well as the final hookup of the launch processing system and GSE. All systems will be checked out and validated in preparation for the September 1982 operational readiness date (ORD).

GSE for the second set of vehicle assembly building high bays will be procured during FY 1982 and installation will begin.

Although the operational readiness date for the pad is in FY 1985, intensive effort must begin in FY 1982 to initiate installation plans and long-lead procurements for GSE. A major effort will be to update the design for Pad B. Design work will be done on the installation contract required to lay out the procedures for installing the GSE at the Pad. Among the many items of GSE to be procured and fabricated, some major GSE procurements for the Pad will be the GOX vent arm, the ET vent arm, the orbiter access arm, and initial procurement for the payload ground handling mechanism (PGHM).

The major effort in the launch control center (LCC) during FY 1982 will be to develop the launch processing system (LPS) software production facility. Long-lead procurements will begin in FY 1981. Additional procurements must be made in FY 1982 and automation development work must be intensified. Firing Room 3 in the LCC will be modified and activated for DOD missions requiring secure launch operations, and Firing Room 2 will be modified to provide launch processing system software production capability. Completion in 1983 is required to support projected launch rates.

Within the last five years, evidence has accumulated indicating that the processing of SRB segments in the VAB poses more of a safety hazard than ~~was~~ originally envisioned. Various studies and hazard analyses have shown that the inadvertent ignition of an SRB segment in the VAB might be catastrophic in terms of **loss** of life and major damage to shuttle flight hardware and to the VAB itself. The actual inadvertent ignition of a seven-foot diameter segment at United Technologies Corporation (UTC) in 1979 has shown that such an ignition is possible, **as** well as sympathetic ignition of other segments. The risk to personnel, flight hardware, and the VAB can be reduced by removing as much SRB segment processing and storage from the VAB as is practicable. Construction in FY 1982 is proposed for a dedicated facility for SRB processing, to include the off-loading, inspecting, and building up of aft segment activities. Funds for these facilities are included in the Construction of Facilities budget. Procurement of hardware and equipment to operate the facility will be initiated in N 1982 within this Research and Development budget to support these SRM operations. Continued engineering and design analyses are required to define the damages that would result from inadvertent SRM ignition in the VAB during solid rocket booster stacking operations. Definition of the hazardous environment will result in identification of potential facility and equipment modification/additions to be initiated during N 1982.

MAJOR PROJECT ACTIVITIES PLANNED IN FY 1982 :

- o Prepare OPF-2 to support prelaunch Orbiter processing by September 1, 1982
- Prepare MLP-2 for September 1982 ORD
- o Update the design for Pad B
- o Securing Firing Room 3 for DOD missions

	1980	1981		1982
	<u>Actual</u>	Budget <u>Estimate</u>	Current <u>Estimate</u>	Budget <u>Estimate</u>
		(Thousands of Dollars)		
Spares and equipment.....	42,900	109,900	102,000	155,000

OBJECTIVES AND STATUS:

Logistics support to the Space Shuttle program requires an initial lay-in of spares adequate for replacement of Shuttle components as they fail in use. Failure rate for each item and the turnaround time for item repair are two significant factors in determining the quantity of initial spares to be procured. Initial spares are considered as an investment in program capability to reach the flight rate and processing time required by the operational mission model.

Initial spares include primarily line replaceable units (LRU's), or those for which the optimum maintenance action is removal from the vehicle and replacement. In some cases, economic analysis supports providing initial spares at the shop replaceable unit (SRU) level as well. The initial spares funding line includes costs of flight spares, GSE spares, and the logistics support analysis to properly estimate and procure these spares.

Tooling modifications required to accommodate the lightweight External Tank (ET) configuration continues both at the Michoud Assembly Facility and at the subsystem hardware vendor facilities. Also, a number of major weld and thermal protection system (TPS) tooling procurements required to achieve higher ET build rates are being initiated. Tooling modifications to accommodate higher build rates are continuing at the SRM subcontractor facilities and at KSC for the SRB subsystem hardware. Crew equipment provides for the certification and verification of the life support system (LSS) and extravehicular mobility unit (EMU, or space suit).

CHANGES FROM FY 1981 BUDGET ESTIMATE:

The initial lay-in of spares, planned in the FY 1981 budget estimate, supported an earlier operational flight schedule. The FY 1981 current estimate has been reduced by \$7.9 million by delaying life support systems (LSS) and space suits planned procurements until FY 1982, and by a rephasing of SRB and ET tooling capabilities to meet the present flight schedule.

BASIS OF FY 1982 ESTIMATE:

Due to the production and procurement lead-times, funding in FY 1981 supports a flight plan of eight operational flights in FY 1982 and FY 1983. These lead-time procurements in FY 1982 are necessary to support the FY 1984 flight rate requirement and the concurrent preparation for increased launch site capability through the second line of GSE spares. Crew related items will also be produced and will result in an EMU space suit inventory of ten training and thirteen flight suits at the end of FY 1982, with all five sizings having at least three suits. This inventory plus the life support system and related spares will support flight and backup crew needs for training through STS-8 and flight through STS-7. Tooling modifications to accommodate higher hardware build rates will continue at ET and SRB prime contractors and subcontractor facilities. A number of external tank weld fixtures and TPS applicator tools will be installed at the Michoud Assembly Facility during FY 1982, leading toward achievement of a production capability of 24 tanks per year.

SPACE FLIGHT
OPERATIONS

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1982 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE TRANSPORTATION SYSTEMS

SPACE FLIGHT OPERATIONS PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1980 <u>Actual</u>	<u>1981</u> Budget Current <u>Estimate</u> <u>Estimate</u> (Thousands of Dollars)		1982 Budget <u>Estimate</u>	Page <u>No.</u>
Space transportation systems operations					
capability development.....	54,100	79,000	81,000	146,200	RD 2-3
Development, test and mission support..	172,600	183,500	183,500	184,000	RD 2-15
Advanced programs.....	13,000	8,800	8,800	10,800	RD 2-20
Spacelab.....	58,800	149,700	139,700	140,700	RD 2-22
Space transportation system operations..	148,100	346,500	270,700	561,300	RD 2-24
 Total.....	<u>446,600</u>	<u>767,500</u>	<u>683,700</u>	<u>1,043,000</u>	
 <u>Distribution of Program Amount by Installation:</u>					
Johnson Space Center.....	143,461	208,300	174,800	237,300	
Kennedy Space Center.....	86,601	138,500	102,400	112,200	
Marshall Space Flight Center..	200,812	397,300	387,200	663,100	
National Space Technology Laboratories ..	5,800	5,200	5,000	5,300	
Goddard Space Flight Center ..	5,143	7,100	5,500	3,800	
Jet Propulsion Laboratory....	55	200	---	---	
Ames Research Center.....	---	---	---	---	
Langley Research Center.....	---	100	---	---	
Lewis Research Center.....	---	---	---	---	
Headquarters.....	4,728	10,800	8,800	21,300	
 Total.....	<u>446,600</u>	<u>767,500</u>	<u>683,700</u>	<u>1,043,000</u>	

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1982 ESTIMATES

OFFICE OF SPACE TRANSPORTATION SYSTEMS

SPACE FLIGHT OPERATIONS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The Space Flight Operations program includes Space Transportation System Operations Capability Development; the common support activities conducted under Development, Test and Mission Support; Advanced Programs; Spacelab ; and Space Transportation System Operations.

Space Transportation Systems (STS) Operations Capability Development provides for space transportation system development activities other than the Space Shuttle. These development and support activities are necessary for the orderly transition to STS operations. Principal areas of activity include the STS Upper stages, Multimission and Payload Support Equipment, Mission Control Center Upgrading (Level 11), Payload and Operations Support, Performance Augmentation, Solar Electric Propulsion System, and STS Operations Effectiveness.

Development, Test and Mission Support provides the common engineering, scientific and technical support required at the Johnson Space Center, the Kennedy Space Center, the Marshall Space Flight Center, and the National Space Technology Laboratories for space transportation systems research and development activities.

The advanced program effort provides technical as well as programmatic data for the definition and evaluation of potential future space missions and systems. In support of this effort, advanced development activities are conducted to provide a basis for obtaining significant performance reliability improvements and reducing future program risks and development costs through the effective use of new technology.

The Spacelab is a major element of the Space Transportation System. The program is being carried out jointly by NASA and the European Space Agency (ESA). NASA's support of ESA's Spacelab development effort includes development of support equipment not provided by ESA. Other activities include procurement of flight hardware and system activation activities which assure Spacelab compatibility with the orbiter leading to an operational capability.

Space Transportation System Operations will provide the transportation services and operational activities to bring about a new era in capitalizing on the unique advantages of space to achieve expansion of human knowledge and practical benefits on Earth. The Space Transportation System Operations activities integrate the Space Shuttle system, the Spacelab, and the Upper Stages into a versatile and economical system; accomplish mission planning; provide the operational recurring hardware and consumables; and support all launch, flight, recovery, crew and related activities.

BASIS OF FY 1982 FUNDING REQUIREMENTS:**SPACE TRANSPORTATION SYSTEMS (STS) OPERATIONS CAPABILITY DEVELOPMENT**

	1980	1981		1982	Page
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>	<u>No.</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>	
		(Thousands of Dollars)			
Space transportaion system upper stages.. .. .	18,300	29,000	31,000	60,000	RD 2-5
Multimission and payload support equipment.. .. .	9,600	13,000	16,500	17,700	RD 2-7
Mission control center (MCC) upgrading (Level II).. .. .	12,900	15,800	15,800	24,800	RD 2-9
Payload and operations support.. .. .	10,900	11,200	7,700	10,700	RD 2-10
Space transportation system operations effectiveness.. .	---	---	---	10,000	RD 2-11
Solar electric propulsion system.....	---	---	7,000	18,000	RD 2-12
Performance augmentation studies.. .. .	<u>2,400</u>	<u>10,000</u>	<u>3,000</u>	<u>5,000</u>	RD 2-13
Total.....	<u>54,100</u>	<u>79,000</u>	<u>81,000</u>	<u>146,200</u>	

OBJECTIVES AND STATUS:

The Space Transportation Systems Operations Capability Development activity includes seven major areas of effort: Space Transportation Systems Upper Stages; Multimission and Payload Support Equipment; the Mission Control Center (MCC) Upgrading (Level II); Payload and Operations Support; Space Transportation System Operations Effectiveness; Solar Electric Propulsion System, and Performance Augmentation. The STS Upper Stages currently under development consist of the Inertial Upper Stage (IUS) and the Spinning Solid Upper Stage (SSUS). They are expendable, propulsive stages required to provide the capability to deploy Shuttle-launched payloads to high energy orbits not attainable by the Shuttle alone. The IUS, being developed under a Department of Defense contract, is a multistage, solid propellant expendable vehicle to become operational on the Titan in 1981 and on the STS in late 1982. Because of recent problems, including revised contractor cost estimates, plans for this upper stage are currently under review. The Spinning Solid Upper Stages (SSUS), being developed by the McDonnell-Douglas Corporation as a commercial venture, are spin-stabilized solid propellant expendable upper stages, sized for Delta and for Atlas-Centaur class payloads, to be launched into geosynchronous orbit.

Multimission and Payload Support Equipment consists of ground and flight hardware used for interfaces between the payloads and the Space Transportation System, as well as test equipment to verify payload integration compatibility. This class of hardware will be developed into a standard, reusable inventory for a variety of payloads.

The Mission Control Center (MCC) Upgrading (Level 11) is the reconfiguration of the Johnson Space Center Mission Control Center to support the STS operational flight schedule requirements. Level II will provide additional hardware, equipment, and software to upgrade the MCC to provide the capability to support two simultaneous orbiter missions, a ground test or simulation network, dual launch site interfaces, and Spacelab and IUS systems monitoring and flight control.

The payload and operations support activity consists of two major efforts; Orbital Flight Test (OFT) Payload Integration and the Payload Operations Control Center (POCC). The Orbital Flight Test Payload Integration provides for the integration of payloads on the OFT flights. The POCC, to be located at the Johnson Space Center, will provide facilities for command and control of Shuttle/Spacelab attached payloads.

STS operations effectiveness involves developing ways to improve the operational performance of the STS in the following areas: vehicle hardware, vehicle turnaround/cargo processing, system software automation, mission operations, and management procedures. These areas will be analyzed to identify candidate improvements for funding priority.

The Solar Electric Propulsion System (SEPS) is an ion propulsion upper stage which will be used to enhance the capabilities of the Space Transportation System (STS). SEPS is designed for high energy planetary missions to reduce trip time and/or increase the amount or size of scientific instruments carried on board the spacecraft. Performance augmentation studies will continue to look at improved Shuttle performance capability options. Improved performance is necessary for certain missions flying out of Vandenberg Air Force Base (VAFB) and to accommodate new payloads and new space utilization concepts.

CHANGES FROM FY 1981 BUDGET ESTIMATE:

The STS operations capability development estimate changes are explained within each project.

BASIS FOR FY 1982 ESTIMATES:

FY 1982 funding for the Multimission and Payload Support Equipment is required for development, initial testing and orbiter installation of Multimission and Payload Support Equipment such as the self-contained payload containers, mission kits and payload specialist station. Testing of the trace gas analyzer and the first set of cargo integration and test equipment will be completed. FY 1982 funds will also provide for the continued design of the mixed cargo hardware and cargo integration and test equipment dual capability.

Upgrading the Mission Control Center (Level II) will continue during FY 1982, with accomplishment of the three-vehicle design review and achievement of the single operations capability. Funds will be required for procurement of hardware including communication interface equipment.

Reconfiguration software development, as well as design, checkout, and testing of the trajectory, telemetry and command software systems will continue.

FY 1982 funds will be used to continue to work toward the completion of the checkout and testing of the POCC in support of the operational flight schedule requirements and for operation of those parts of the POCC which will support the orbital flight test mission payloads. Orbital Flight Test Payload Integration funding in FY 1982 is required for the integration and handling of payloads for the OFT missions in 1982.

FY 1982 funding will be used to initiate design and development of improvements to the Space Transportation System to achieve operational and cost effectiveness. Areas currently identified include standardized payload interfaces, upper stage facility pathfinders, improvement of the cargo integration test equipment, and rotating service structure interface, systems software automation, and various vehicle hardware improvements. In addition, funds will be used for studies which focus on efficient and cost effective modes of operating the Space Transportation System.

	1980	1981		1982
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of Dollars)		
Space Transportation System (STS) Upper Stages.. .. .	18,300	29,000	31,000	60,000

OBJECTIVES AND STATUS:

The STS upper stages are required to deploy Shuttle-launched payloads to orbits not attainable by the Shuttle alone. These stages are the Inertial Upper Stage (IUS) and the Spinning Solid Upper Stages (SSUS).

The IUS is being developed under a Department of Defense contract, to meet upper stage requirements for heavy payloads to be placed in high Earth orbit with a modified version being developed to meet planetary mission requirements. The plans and possible options for meeting planetary mission requirements are presently under review, primarily because of revised cost estimates recently received from the contractor. This review is expected to be completed in early 1981.

The IUS payload capability exceeds the capability needed by many geosynchronous payloads using today's expendable launch vehicles. The SSUS is being developed commercially for these smaller payloads in two weight classes. The Delta

class, **SSUS-D**, will be capable of injecting up to 2,750-pound payloads into geosynchronous transfer orbit. The Atlas-Centaur class, **SSUS-A**, will be capable of injecting 4,400-pound payloads into the same orbit. Spacecraft apogee motors place the spacecraft (1,400 and 2,250 pounds respectively for **SSUS-D** and **SSUS-A**) into final geosynchronous orbit. The **SSUS-A** and **SSUS-D** offer launch economies to the user community. These relatively low cost upper stages have simple physical and functional interfaces for payloads and facilitate an early and orderly transition from the current expendable launch vehicles to the operational STS. Two **SSUS-A**'s or four **SSUS-D**'s with their spacecraft can be flown on a single Shuttle flight. As a result, the launch costs to the user can be significantly reduced. The **SSUS** emphasis is on servicing the commercial spacecraft user and his requirements.

The commercial development of the **SSUS-A** and **SSUS-D** by the McDonnell Douglas Corporation is proceeding on schedule to meet anticipated launch requirements. The design has been completed and critical design reviews accomplished. Materials and components have been procured, and most elements are manufactured and ready for assembly. **SSUS-D** motor development and qualification has been completed. Testing to determine the spacecraft vibration environment induced by **SSUS-A** motor burn and means for suitable attenuation were completed in September. The qualification program has been the principal **SSUS** development activity during 1980 and will continue through FY 1981. A Satellite Business System spacecraft was successfully launched in November 1980 on board a Delta expendable launch vehicle utilizing a Delta payload assist module (which is the **SSUS-D** configuration used with the Delta expendable launch vehicle).

CHANGES FROM FY 1981 BUDGET ESTIMATES:

The current N 1981 estimate is based on the requirement for continuing the IUS development as understood at the beginning of FY 1981. Increases Over the FY 1981 budget estimate resulted from continued IUS development problems and design changes, primarily, the design change requirement for three-axis stabilization of the IUS third stage versus the spin stabilization baseline plan for NASA planetary missions. As a result of a recent revision of estimated costs by the development contractor, plans for the IUS and possible alternatives for high energy missions are under review. Results are not expected until early 1981.

BASIS OF FY 1982 BUDGET EST

FY 1982 STS upper stages funding is required to support the development of a NASA-unique capability. The FY 1982 estimate of \$60 million is based on requirements for continuing the IUS development and specific plans and requirements will be subject to the results of the review currently in progress.

	1980	1981		1982
	<u>Actual</u>	<u>Budget</u> <u>Estimate</u>	<u>Current</u> <u>Estimate</u>	<u>Budget</u> <u>Estimate</u>
		(Thousands of Dollars)		
Multimission and Payload Support equipment.. .. .	9,600	13,000	16,500	17,700

OBJECTIVES AND STATUS:

Multimission and payload support equipment consists of equipment required to integrate and check out payload elements, and a class of ground and flight hardware that will provide an interface between payloads and elements of the Space Transportation System (STS). These requirements can be satisfied more economically from a standard equipment inventory than by individual payload users. This reusable equipment is being developed to integrate, check out, transport, and operate a wide range of applications, science, and technology payloads.

Examples of this type of standardized equipment are:

(1) Payload Transportation Equipment: Intrasite payload equipment is being developed for use at the launch site to transport cargoes to and from the Shuttle orbiter. Ground and flight transportation equipment will also be used for cross-country transportation of payloads (regular and outsized) to and from the Kennedy Space Center and the Western Space and Missile Center.

(2) Payload Specialist Station Equipment: This equipment is required to conduct payload operations from the orbiter's aft flight deck. A concept utilizing existing technology has been defined and will satisfy the majority of payload functional command and display requirements, as well as mixed cargo integration and operations on early STS missions. This approach will minimize the need for payload-unique equipment and operational changeout time.

(3) Mixed Cargo Support Equipment: This equipment will provide maximum flexibility for mixing cargoes in the orbiter bay, as well as decreasing installation and checkout time. The use of identical equipment for different payload configurations will allow simple crew interface and training. Examples of this equipment include standard cable harnesses which will allow command and data feedback simultaneously for up to four payloads in the orbiter cargo bay; and timing buffers which will provide various time signals to the Shuttle-attached payloads while they are active.

(4) Flexible Multiplexer/Demultiplexer: The flexible multiplexer will combine the orbiter data stream and up to five separate payload telemetry or command data streams into a single output signal. The function of the flexible demultiplexer is to separate the combined data signal, either telemetry or command, back into the appropriate orbiter or payload data streams.

(5) Cargo Integration and Test Equipment (CITE): This equipment is used to integrate and check out payload elements as they are assembled into a complete cargo to be flown on the space transportation system. CITE will verify the compatibility of the cargo to Shuttle interfaces, and assure that cargo elements do not interfere with each other.

(6) Trace Gas Analyzer: The trace gas analyzer system will perform in-flight monitoring of the aggregate "offgassing" constituents from payloads and metabolic sources in the Spacelab pressurized module. Its primary subsystems consist of a gas chromatographic column to detect the presence of an atmospheric substance and a mass spectrometer to measure the concentration of each of the atmospheric constituents.

(7) Mission Kits: The mission kits consist of standard and optional flight hardware designed to extend the capabilities of the payload and orbiter to support the mission as dictated by the payload requirements. Examples of these items are self-contained payload containers and nitrogen tanks.

In 1981, manufacture of multimission and payload support equipment such as the intersite transportation equipment and the trace gas analyzer will be completed. Other activities include activation of the first set of cargo integration and test equipment; initial design and development of the dual CITE capabilities; continued design of the mixed cargo hardware, mission kit equipment and the self-contained payload containers; and continued development of the payload specialist station.

CE FROM FY 1981 BUDGET ESTIMATE:

The multimission and payload support equipment estimate for FY 1981 has been increased because of the rebaselined trace gas analyzer system, the increased requirements of the basic and dual cargo integration and test equipment, and student experiments.

BASIS OF FY 1982 ESTIMATE:

FY 1982 funds are required for development, initial testing and orbiter installation of multimission and payload support equipment such as the self-contained payload containers, mission kits, and payload specialist station. Testing of the trace gas analyzer and the first set of cargo integration and test equipment will be completed. FY 1982 funds will also provide for the continued design of the mixed cargo hardware and cargo integration and test equipment capability.

	1980	1981		1982
	<u>Actual</u>	Budget <u>Estimate</u>	Current <u>Estimate</u>	Budget <u>Estimate</u>
		(Thousands of Dollars)		
Mission Control Center (MCC) Upgrading (Level 11).....	12,900	15,800	15,800	24,800

OBJECTIVES AND STATUS:

Mission Control Center (MCC) Upgrading (Level II) is the reconfiguration of the Johnson Space Center (JSC) Mission Control Center to support the STS operational flight schedule requirements. Flight-to-flight reconfiguration of the MCC must be automated to support the flight rate. MCC Level I, funded under the Shuttle development program, provides hardware and software to configure the MCC to support Shuttle development flights. The MCC during the operational era will require additional flight control rooms, support rooms, hardware and software to accommodate two simultaneous orbiter missions, a ground test or simulation network, dual launch site interfaces, and Spacelab and IUS systems monitoring and flight control.

Upgrading the Mission Control Center (Level 11) at JSC will continue in FY 1981 with the completion of detailed systems design for dual vehicle command and control. Development and implementation for dual vehicle command and control will progress towards initial operational capability. Development completion and initial testing of the flight planning system 11, consisting of flight design and crew activity planning elements, will be achieved in support of early flight rate requirements.

BASIS FOR FY 1982 ESTIMATE:

Upgrading the Mission Control Center (Level II) will continue during FY 1982, with accomplishment of the three-vehicle design review and achievement of the single operations capability. Funds will be required for procurement of hardware including communication interface equipment.

Reconfiguration software development, as well as design, checkout, and testing of the trajectory, telemetry, and command software systems will continue.

	1980	1981		1982
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of Dollars)		
Payload and Operations Support.....	10,900	11,200	7,700	10,700

OBJECTIVES AND STATUS:

The Payload and Operations Support activity consists of two major areas of effort: Payload Operations Control Center (POCC) and Orbital Flight Test (OFT) payload integration.

The POCC, to be located at the Johnson Space Center (JSC), will provide for command and control of attached payloads that operate in the Shuttle and Spacelab. It will operate in conjunction with the JSC Mission Control Center. Funding is required for the acquisition of computers, displays, communication links, and associated software.

In FY 1981, development of hardware and software systems for the POCC at JSC will continue in order to allow payload command and control and some real-time data review and analysis, and analytical integration activities will be completed for the orbital flight test payloads.

The OFT payload integration provides for the integration of payloads on the OFT flights. The activities include management integration such as planning, scheduling, and coordinating all elements; interface definition in environmental, structural and thermal areas; safety analysis; hardware integration; flight support; and development of the interface control document. The FY 1981 funds will continue to support conceptual flight planning, launch site planning, and thermal and loads analysis for payloads to be flown on the Shuttle orbital flight test missions.

CHANGES FROM FY 1981 BUDGET ESTIMATE:

The POCC estimate for FY 1981 has been rephased to be consistent with the current launch readiness date for Spacelab-2. The operation management support studies were deleted from the FY 1981 budget.

BASIS OF FY 1982 ESTIMATE:

FY 1982 funds will be used to continue to work toward the completion of the checkout and testing of the Payload Operations Control Center in support of the operational flight schedule requirements and for operation of those parts of the POCC which will support the OFT mission payloads. OFT payload integration funding in FY 1982 is required for the integration and handling of payloads for the OFT missions in 1982.

	1980	1981		1982
	<u>Actual</u>	<u>Budget</u> <u>Estimate</u>	<u>Current</u> <u>Estimate</u>	<u>Budget</u> <u>Estimate</u>
		(Thousands of Dollars)		
Space Transportation System Operations Effectiveness..	---	---	---	10,000

OBJECTIVES AND STATUS:

Effective utilization of the space transportation system (STS) is necessary to meet future operational requirements and to provide services at the lowest cost possible. Effective utilization is advanced through analysis, design, development, and procurement activities dedicated to improving the capability and overall performance of the STS. Significant potential exists for improvement of operational performance of the STS in the areas of vehicle hardware, vehicle turnaround/cargo processing, system software automation, mission operations, and management procedures. Improvement will be accomplished by taking advantage of advances in electronics, electromechanical devices, propulsion, logistics, software, vehicle processing, and management techniques.

Beginning in 1982, STS operations effectiveness will identify improvements to vehicle hardware and the existing operational procedures/policies and will implement efforts toward achieving operational effectiveness. The aforementioned areas in which improvements in effectiveness would potentially benefit the STS will be analyzed to identify areas for funding priority.

BASIS FOR 1982 ESTIMATE:

FY 1982 funding will be used to initiate design and development of improvements to the STS to achieve operational effectiveness. Areas currently identified include standardized payload interfaces, upper stage facility pathfinders, improvement of the cargo integration test equipment, and rotating service structure interface, systems software automation, and a list of approximately fifty vehicle hardware improvements. In addition, funds will be used for studies which focus on efficient and cost effective modes of operating the STS.

	1980	1981		1982
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of Dollars)		
Solar Electric Propulsion System.....	---	---	7,000	18,000

OBJECTIVES AND STATUS:

The Solar Electric Propulsion System (SEPS) is an upper stage to be used to augment the capabilities of the space transportation system (STS). The SEPS converts solar energy into ion propulsion for a major advance in space propulsion. SEPS is required for a range of advanced planetary and Earth orbit missions. Planetary missions will benefit from SEPS capabilities in terms of improvements in flight trajectories, long duration maneuvering capabilities for rendezvous with planets and other bodies of the solar system, and from a widening of launch windows which currently limit the conduct of planetary missions. The SEPS will also provide a major increase in capabilities for transportation to a geosynchronous orbit.

The technology supporting SEPS has been in development since the late 1960's. Key elements such as the solar arrays, power processors and ion thrusters, have been tested and demonstrated to meet performance and weight objectives. Life tests are progressing well and will continue for approximately another year.

The FY 1980 competitive studies, funded in the advanced programs area, have established baseline configurations required to meet mission requirements, and have identified critical design characteristics, and potential problem areas. These program definition studies will be completed in early FY 1981 and will establish implementation plans and requirements. The program will proceed into the development phase in FY 1981. A request for development proposals will be issued, a single contractor will be selected, and initial development activities will be started in FY 1981.

CHANGES FROM FY 1981 BUDGET ESTIMATE:

The FY 1981 current estimate of \$7.0 million reflects Congressional action to provide funds to permit undertaking SEPS detail design and development in FY 1981.

BASIS OF FY 1982 ESTIMATE:

The FY 1982 funding will provide for continuation of the SEPS development activities on a schedule paced to support initial flight readiness in 1986. FY 1982 funding continues the system and subsystem design process, procures long lead time hardware and materials, finalizes spacecraft-to-SEPS, and SEPS-to-STs interfaces requirements. The system requirement review will be conducted in FY 1982 and the preliminary design review will occur in late FY 1982 or early 1983.

	1980 <u>Actual</u>	<u>Budget</u> <u>Estimate</u> (Thousands of Dollars)	<u>Current</u> <u>Estimate</u> (Thousands of Dollars)	1982 <u>Budget</u> <u>Estimate</u>
Performance Augmentation Studies.....	2,400	10,000	3,000	5,000

OBJECTIVE AND STATUS:

As Shuttle development has progressed, it has become clear that the required payload capability may not be sufficient for certain important missions to be launched primarily from the Vandenberg Air Force Base (VAFB). This deficiency results primarily from increases in orbiter weight as a result of design and equipment changes. Approved payload programs scheduled for early STS operational flights from VAFB can be accommodated by the Shuttle with currently projected performance capability by limiting certain single payloads to that capability, by restricting the total cargo weight for multiple payload missions, and by limiting the experiment weights and/or durations of Spacelab missions. However, these limitations reduce cost effectiveness and prevent full utilization of the design potential of the STS and its new and unique capabilities. Additional performance is necessary to ensure that the full STS payload deployment capability of 32,000 pounds and retrieval capability of 25,000 pounds can be achieved for the 98 degree inclination, 150 nautical mile circular mission launched from VAFB. The current projected capability is not sufficient to perform this mission. Consequently, it is important to the future national space capability that performance augmentation be developed and made available to support payload requirements which exploit the full capability of the STS. The FY 1982 estimate will permit augmentation of STS to meet all design and performance requirements and offers the potential to accommodate payload growth, new payloads, and new concepts.

NASA performed preliminary evaluations of alternative performance augmentation concepts during 1979 and 1980 with the objective of achieving this capability by mid-1985. The most promising of these alternatives from the standpoint of minimum development risk and STS impact was a concept of solid rocket motor strap-ons to the Solid Rocket Booster (SRB) and/or the External Tank (ET), and a liquid rocket engine package placed under the ET. Based on the 1985 objective date, this Liquid Boost Module (LBM) concept for STS performance augmentation was adopted as the baseline concept for

further study. The LBM concept would employ existing Titan engines and tankage, modified as required, to be mounted under the ET. The objective date for full capability at VAFB has been extended until 1986 allowing for consideration of other performance augmentation options with longer development lead times such as uprating the main engines (SSME's) to the range of 115 percent of Rated Power Level (RPL) for nominal operation, and Solid Rocket Motor (SRM) filament wound case segments. These candidate options and combinations of options, including the LBM concept, will be studied in detail during N 1981 and N 1982 to allow concept selection for a mid-1986 objective date.

FY 1981 work includes systems engineering tests and wind tunnel and model tests, structural and aerodynamic loads analyses, and Phase B studies to identify the design specification and performance requirements for the various performance augmentation options under consideration. The FY 1981 effort will also consist of systems engineering activities to understand the aerothermal, structural, dynamic, and vibroacoustic impact of performance augmentation options on the STS elements. Facility requirements will also be studied.

CHANGES FROM FY 1981 BUDGET ESTIMATE:

The reduction of \$7 million in N 1981 reflects implementation of the general reduction resulting from Congressional action on the N 1981 appropriation request. This reduction can be taken in this area because of an extension of the first potential mission date for the augmented performance from 1985 to 1986.

BASIS OF FY 1982 ESTIMATE:

Funds in FY 1982 are required to complete the preliminary efforts necessary to allow concept selection and readiness for a N 1983 development start in order to achieve operational capability in 1986. Activities started in FY 1980 and FY 1981 must continue in N 1982 to conclude the detail studies and analyses of the candidate performance augmentation options including study of the impact on each element (orbiter, external tank, and solid rocket booster), as well as the impact on the overall system and launch facility.

BASIS OF FY 1982 FUNDING REQUIREMENTS:**DEVELOPMENT, TEST AND MISSION SUPPORT**

	<u>1980</u> <u>Actual</u>	<u>1981</u> Budget <u>Estimate</u> (Thousands of Dollars)	Current <u>Estimate</u>	<u>1982</u> Budget <u>Estimate</u>	Page <u>No.</u>
Research and test support.....	31,401	32,400	35,800	35,900	RD 2-16
Data systems and flight support.....	35,822	40,200	38,900	35,700	RD 2-17
Operations support.....	44,285	45,900	45,900	49,500	RD 2-18
Launch systems support.....	<u>61,092</u>	<u>65,000</u>	<u>62,900</u>	<u>62,900</u>	RD 2-19
Total.....	<u>172,600</u>	<u>183,500</u>	<u>183,500</u>	<u>184,000</u>	

OBJECTIVES AND STATUS:

Development, Test, and Mission Support (DTMS) provides the common engineering, scientific and technical support required to conduct ongoing and proposed Space Transportation Systems (STS) research and development at the Johnson Space Center, the Kennedy Space Center, the Marshall Space Flight Center, and the National Space Technology Laboratories. DTMS functions include research and test support, data systems and flight support, operations support, and launch systems support. These common efforts are necessary to support early project definition, to provide engineering support for indepth technical examination of development efforts of prime contractors and major subcontractors on STS projects, to provide common support equipment and supplies, and to perform alternative designs, testing, and analyses in high technology areas of design and development.

CHANGES FROM FY 1981 BUDGET ESTIMATE:

The total funding for DTMS has not been changed in FY 1981. There has been a reallocation within the total estimate consistent with the requirements to support certification and verification of the Space Shuttle systems, the delay in the STS-1 launch schedule, and the extension of the orbital flight test program.

BASIS OF FY 1982 ESTIMATE:

FY 1982 funding provides for the common engineering, scientific, and technical support required for activities performed in the Shuttle program, the STS Operations Capability Development program and advanced programs.

	1980 <u>Actual</u>	1981 <u>Budget Estimate</u> <u>Current Estimate</u> (Thousands of Dollars)		1982 <u>Budget Estimate</u>
Research and Test Support.. .. .	31,401	32,400	35,800	35,900

OBJECTIVES AND STATUS:

Research and test support encompasses a broad spectrum of technical, engineering, scientific, reliability and quality assurance, and safety operations. These activities complement the work of the major development contractors located across the country in contractor plants and United States government facilities. Johnson Space Center in FY 1981 continues certification and verification of flight and ground hardware and operation of the water immersion facility, crew training station, and the remote manipulator simulator for training. Marshall Space Flight Center supports the Shuttle main engine static test firing activities and integrated component testing as well as the qualification of the main propulsion system, refurbishment efforts for the solid rocket booster, and provides flight evaluation of the external tank, solid rocket booster, main engine, and related systems.

CHANGES FROM THE FY 1981 BUDGET ESTIMATE:

The current estimate for FY 1981 has increased by \$3.4 million primarily due to additional certification and verification requirements for crew equipment (i.e. extravehicular mobility unit), orbiter thermal protection system, and orbiter structural load analysis.

BASIS OF FY 1982 ESTIMATE:

During FY 1982, research and test support efforts will be focused primarily on critical Shuttle activities, including the Shuttle orbiter flight test activity. Also supported will be design and development activities and research and development efforts in STS operations capability development and advanced programs. Engineering and test support is provided to assure achievement of technical goals as they relate to each program.

FY 1982 activities support the operation of training facilities; continued certification and verification of flight and ground hardware, static firing of the Space Shuttle main engine to full power level; refurbishment of solid rocket boosters, support development of the lightweight external tank, and premission, mission, and post mission analysis; and engineering support.

	1980	1981		1982
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of Dollars)		
Data Systems and Flight Support.. .. .	35,822	40,200	38,900	35,700

OBJECTIVES AND STATUS:

Data systems and flight support efforts are associated with the ground-based flight data systems, flight simulation systems, special purpose and general purpose data systems, and flight support.

The ground-based flight data systems effort supports the definition, design, implementation, and checkout of hardware and software modifications to the Johnson Space Center's Mission Control Center, including the real time computer complex in support of the Shuttle orbital flight tests, as well as operation and maintenance of those facilities in preparation for operational mission support. Also included is the operation of the Johnson Space Center central data computation facility and special purpose data system required to support Center-wide activities in mission analysis, systems engineering development, and test functions for the Shuttle program.

Flight support provides for development of Shuttle flight control and recovery plans and procedures, flight plans, flight data compilation, crew procedures and training, and other elements of the data base required for crew activities, operation and maintenance of the T-38 training aircraft, flight data management, and support of Shuttle payload accommodation and integration.

CHANGES FROM FY 1981 BUDGET ESTIMATE:

The FY 1981 estimate has been reduced by \$1.3 million consistent with the workload adjustments reflecting the delay in the STS-1 launch schedule.



BASIS OF FY 1982 ESTIMATE:

FY 1982 funding of ground-based flight data systems supports the operations and capability upgrading of the Mission Control Center, the central computing facility, and the flight support and flight data management functions for the OBT effort.

		<u>1980</u>	<u>1981</u>		<u>1982</u>
		<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
			<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
			(Thousands of Dollars)		
Operations Support.....	.....	44,285	45,900	45,900	49,500

OBJECTIVES AND STATUS:

Operations support provides for contractor effort and related supplies and equipment to operate and maintain on-site activities at the Johnson Space Center, the Marshall Space Flight Center, the Kennedy Space Center, the National Space Technology Laboratories, and for off-site operations at the White Sands Test Facility.

BASIS OF FY 1982 ESTIMATE:

FY 1982 funding will provide for the maintenance of technical facilities and equipment, chemical cleaning, engineering design, technical documentation and analyses, telecommunications, component fabrication, photographic support, and logistics support. Examples of specific services to be provided in FY 1982 include: (1) operation and maintenance of specialized electrical and cryogenic systems, and maintenance of test area cranes; (2) operation of shops to do metal refurbishing, anodizing, plating, stripping, and etching of selected items of in-house fabricated flight hardware; (3) cleaning of hoses, gauges, tubing, and related flight items that are fabricated in-house; (4) engineering, installation, operation, and maintenance of closed circuit fixed and mobile television required for support and/or surveillance of tests; (5) photographic services, including still and motion picture processing, and audio visual mission support; (6) fabrication of models, breadboards, and selected items of flight hardware; (7) technical documentation services, telecommunications, and graphics; (8) technical services in support of center operations including receipt, storage and issue of research and development supplies and equipment, and transportation services; and (9) management services in support of center operations, including data management, microfilming, and preparation of technical documentation.

In addition, FY 1982 funds will provide the basic level of support at the National Space Technology Laboratories for static test firing at full power level of the main propulsion system and integrated component testing of the Space Shuttle main engine.

	1980	1981		1982
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of Dollars)		
Launch Systems Support.	61,092	65,000	62,900	62,900

OBJECTIVES AND STATUS:

Launch systems support provides for the development and test of the checkout and launch facilities and associated ground support equipment, as well as the technical services required to support the test, checkout, and launch of the Shuttle and payloads for the development test flights.

CHANGES FROM FY 1981 BUDGET ESTIMATE:

The FY 1981 estimate has been decreased by \$2.1 million to reflect primarily the deferred buildup of support activities required for STS-1 launch processing.

BASIS OF FY 1982 ESTIMATE:

The FY 1982 launch systems support requirements at the Kennedy Space Center will support the integration and checkout of the space vehicle, its payloads, and ground support systems to accommodate the Shuttle orbital flight test hardware and payload systems.

Funding in FY 1982 will provide for mechanical ground system activities involving operation and maintenance of launch systems and facilities for the Shuttle; support for development testing of the Kennedy Space Center designed Space Shuttle equipment in the launch equipment test facility; maintenance and operation of the Kennedy Space Center electrical and mechanical utilities systems; and operation of technical shops and the precision cleaning laboratory which supports maintenance activities.

FY 1982 funding will also support the electronic and launch instrumentation systems, such as automated checkout equipment, operational voice and television communications, measurements, and telemetry. These activities include operations and maintenance support of communication, computational and instrumentation systems for the Space Shuttle, and instrumentation and measurement support for development testing of the Kennedy Space Center designed Space Shuttle equipment in the launch equipment test facility.

BASIS OF FY 1982 FUNDING REQUIREMENTS:

	<u>ADVANCED PROGRAMS</u>			
	<u>1980</u> <u>Actual</u>	<u>1981</u>		<u>1982</u>
		<u>Budget</u> <u>Estimate</u>	<u>Current</u> <u>Estimate</u>	<u>Budget</u> <u>Estimate</u>
		(Thousands of Dollars)		
Advanced Programs	13,000	8,800	8,800	10,800

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The principal objective of advanced programs is to provide technical and programmatic data for the definition and evaluation of potential future space programs and systems. Future systems requirements, cost and capabilities are identified to provide the basis for selection of new flight systems. These efforts have continually provided the basis for new programs and systems, such as Apollo, Skylab, and the Shuttle. Subsystems studies and supporting development activities are conducted to demonstrate significant performance and reliability improvements and to reduce future program risks and development costs through the effective use of new technologies.

In FY 1981, the advanced programs effort will be focused on conducting system and subsystem development studies for the definition of power systems, space platforms for low and geosynchronous orbits and tether systems; the continued evaluation of major regenerative life support subsystems; assembly and construction operations for large space systems and structures in orbit; the investigation of systems and subsystems concepts involving satellite services (i.e., placement, retrieval, and on-orbit maintenance and repairs); the definition of advanced transportation vehicle concepts including orbital transfer vehicles and Shuttle-derived launch vehicles; and the definition and analysis of satellite placement and retrieval systems remote from the orbiter. Completion of the alternative systems concept studies for the 25-kW power system definition will be accomplished by December 1981.

BASIS OF FY 1982 ESTIMATE:

In FY 1982 major emphasis will be placed on continuing studies, engineering investigations, and definition of mission options that will soon be possible and required because of the operational capability and flexibility of the space transportation system. These options will generally fall into four major categories: unmanned low-altitude platforms, unmanned geostationary platforms, a manned space operations center, and various elements of orbital test and transportation for their support. In the unmanned low-altitude platforms area, design will be continued to define platform and power support systems. In the second category, definition studies of geosynchronous platforms will be

emphasized. To achieve the eventual capability of manned operations centralization and commonality in orbit, the concept of the Space Operations Center, a Shuttle-serviced, permanent manned low-altitude facility, is under continuing study. The Space Operations Center will improve the efficiency of orbital operations such as: on-orbit assembly, launch, recovery and servicing of manned and unmanned spacecraft; construction, checkout, and transfer to operational orbit of large complex space systems; tending of co-orbiting free-flying satellites and platforms; and continuing development of our capability to conduct permanent manned operations in space. For orbital test and transportation, the focus will be on large structures, satellite servicing, and advanced transportation options.

As part of the orbital test and transportation category, definition studies of life and crew support engineering activities required for extended orbital missions will be conducted. Investigations of potential tools and equipment for use in extravehicular activity and teleoperator operations will be carried out. Also, systems, subsystems, and engineering development studies to support deployable and erectable space structure activities will be continued. As part of construction operations, studies of assembly and repair of future structures in space will be continued as well as studies of extravehicular activity operations essential for satellite and platform maintenance. Concept and engineering development efforts on teleoperator systems to permit remote satellite servicing and studies on extravehicle activity support equipment as well as automated rendezvous and proximity operations techniques will be continued. Advanced space transportation capabilities definition studies will also be conducted to develop candidates for orbital testing of systems and end items that lie between Phase B and Phase C of the usual development approach in order to test feasibility and capability. Other planned activities for FY 1982 in this area include the continuation of studies of advanced transportation to enhance the space transportation system capabilities and to permit improved geosynchronous operations. As part of these efforts, emphasis will be placed on upper stages such as the advanced Centaur, various approaches to a reusable orbital transfer vehicle, and the concept of a Shuttle-derived heavy lift launch vehicle.

BASIS OF FY 1982 FUNDING REQUIREMENTS:

SPACELAB

	1980 <u>Actual</u>	1981 <u>Budget</u> <u>Estimate</u> (Thousands of Dollars)	1981 <u>Current</u> <u>Estimate</u>	1982 <u>Budget</u> <u>Estimate</u>
Spacelab.....	58,800	149,700	139,700	140,700

OBJECTIVES AND STATUS:

The Spacelab is a major element of the Space Transportation System. The program is being carried out jointly by NASA and the European Space Agency (ESA) to provide a versatile, reusable space laboratory which will be flown to and from Earth orbit in the cargo bay of the Shuttle. The Spacelab will consist of a pressurized module and unpressurized pallet segments which can be used in various combinations to support mission requirements. It will permit researchers to conduct a wide range of experiments in a ground-type laboratory while operating in the unique environment of space.

Ten European nations, nine of which are members of the European Space Agency, are participating in the program. NASA and ESA are committed to bear the cost of their respective program responsibilities. ESA responsibilities include the design, development, production, and delivery of the first Spacelab and associated ground support equipment, and establishment of the capability to produce additional Spacelabs. NASA funding responsibilities include development of flight and ground support equipment not provided by ESA, development of Spacelab operational capability and procurement of additional hardware needed to support NASA's missions.

In FY 1981, the manufacture of the crew transfer tunnel will continue and the flexible section will be delivered. The tunnel will link the Spacelab module to the Shuttle orbiter cabin. With the design complete, the fabrication of the Verification Flight Instrumentation (VFI) equipment will start. The VFI includes sensors, electronic measuring and monitoring devices, and related flight and ground support equipment required to verify the performance of Spacelab subsystems and to monitor the environment to which payloads will be subjected.

Development and integration of the software for the Spacelab simulator will continue in FY 1981. The utility kits, which serve as Spacelab-to-Shuttle orbiter mating hardware, will also continue to be manufactured.

NASA will accept delivery of the ESA-developed Spacelab engineering model in early FY 1981. The first flight unit and two sets of ground support equipment are also scheduled for delivery in FY 1981. These deliveries will accelerate Spacelab activities at the Kennedy Space Center involving the receipt, assembly, installation, checkout, and processing of this hardware. Ground support equipment and facility verification testing will be accomplished certifying that the complex is ready for Spacelab launch checkout processing. This work is performed by the Spacelab integration contractor who **will also be** performing systems engineering, logistics planning, systems software preparations and analytical experiment integration for early Spacelab missions.

NASA signed a contract with ESA in early FY 1980 for the procurement of the second set of Spacelab hardware (the first being that which ESA has funded). The production of this follow-on hardware is planned to be completed in FY 1984.

CHANGES FROM 1981 BUDGET ESTIMATES:

As a result of Congressional authorization and appropriation actions, the FY 1981 Spacelab follow-on procurement increment was reduced by \$10 million. This reduction will not significantly affect delivery schedules, but will require rephasing of payments to ESA.

BASIS OF FY 1982 ESTIMATE:

FY 1982 funding is required to continue the procurement of the Spacelab follow-on hardware from ESA. This procurement includes a second set of flight elements and initial spares to support the early flights. Delivery of this hardware is scheduled to begin in N 1982.

Work will continue on the crew transfer tunnel and the Spacelab simulator with FY 1982 funding. The first tunnel is scheduled to be complete and the simulator is to be ready for training in FY 1983. Fabrication of the Spacelab Verification Flight Instrumentation equipment is scheduled to be complete in FY 1982. The manufacture of ground support equipment **will** continue with elements to be delivered in FY 1982 and FY 1983. FY 1982 funding will support the procurement of spare parts for ESA pallet structures which NASA has modified to be flown during the orbiter flight tests. It also provides funds for spares manufactured in the United States for Spacelab flight hardware to be flown on the first two Spacelab missions.

The design of Spacelab flight hardware is well defined. During the preparation for launch, experience has shown that minor changes may be required to assure proper function, compatibility and reliability. FY 1982 funding is required to perform these modifications to the hardware delivered from ESA and the follow-on hardware being procured from ESA.

The Spacelab integration contractor will, with FY 1982 funds, continue to perform the integration of the flight hardware for the first Spacelab missions. The contractor will certify for reflight the pallets which are to be flown during the orbiter flight tests. FY 1982 funds will provide for the preparation of procedures for processing and testing flight and ground hardware. *Also*, effort will be continued in the areas of system engineering, logistics planning and analytical integration for early missions.

BASIS OF FY 1982 FUNDING REQUIREMENTS:**SPACE TRANSPORTATION SYSTEM OPERATIONS**

	1980	1981		1982	Page
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>	<u>No.</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>	
		(Thousands of Dollars)			
Shuttle operations.....	119,300	296,000	213,500	461,100	RD 2-26
Spacelab operations.....	---	1,600	---	---	---
Upper stages operation.....	18,700	30,900	38,200	68,000	RD 2-27
Payload support operations.....	<u>10,100</u>	<u>18,000</u>	<u>19,000</u>	<u>32,200</u>	RD 2-28
Total.....	<u>148,100</u>	<u>346,500</u>	<u>270,700</u>	<u>561,300</u>	

OBJECTIVES AND STATUS:

Space Transportation System Operations will provide the transportation services and operational activities to bring about a more effective access to, and utilization of space for the expansion of human knowledge and for practical benefits on Earth, while reducing the cost of space operations. The space transportation system will provide for the delivery of free-flying payloads to low Earth orbit; facilitate the conduct of experiments using the Shuttle orbiter as a carrier vehicle for experiments mounted in Spacelab pressurized modules and on Spacelab pallets in the orbiter payload bay; deliver payloads to synchronous and other high energy orbits using the combined capabilities of the Shuttle and upper stages; retrieve free-flying payloads from low Earth orbit; and provide on-orbit servicing of satellites.

The space transportation system operations activities integrate the Shuttle system, the Spacelab, and the upper stages into a versatile and economical space transportation system. Shuttle mission planning, procurement planning of recurring hardware and consumables, and support planning for operations involving launch, flight recovery crews and related activities are well underway. In addition, procurement of long-lead items for major expendable hardware components has been initiated.

Spacelab operations provide for development and implementation of Spacelab ground-turnaround and flight operations, including mission planning, Spacelab-to-Shuttle integration, and ground support operations. Upper stage operations provide for the procurement of upper stage hardware and related support necessary for orbital placement of spacecraft.

following low orbit deployment from the Shuttle orbiter. The upper stages include inertial upper stages and spinning solid upper stages.

Payload support operations provide for operational payload related hardware, services and launch site capability development required to meet a user's transportation requirements outside the scope of currently defined standard space transportation system services.

CHANGES FROM 1981 BUDGET ESTIMATES:

FY 1981 funding for Shuttle operations and Spacelab operations were rephased to reflect current requirements consistent with the Shuttle flight manifest covering the planned schedule and payloads for early operational missions. Upper stage operations funding reflects amounts which had been estimated as required for IUS procurement. At present, the estimated costs and alternatives in this area are under review as a result of a recently announced contract overrun. Payload support operations FY 1981 funding reflects increased analytical integration activities but does not include any impact from the current review of upper stage requirements.

BASIS OF FY 1982 BUDGET ESTIMATES:

Shuttle operations - FY 1982 funding is required for continuation of procurement of raw materials and subassemblies for external tanks and solid rocket boosters as well as manufacture, assembly, and checkout of this flight hardware to support the currently planned flight rate for early operational missions. The production phasing is a function of these mission requirements in conjunction with the need to develop a reasonably smooth and efficient buildup of production rates. FY 1982 funding is also required for flight operations planning at Johnson Space Center which includes mission operations planning, crew training, engineering support and analytical integration for initial operational flight beginning in late 1982.

Upper stage operations - Funding in FY 1982 is required to continue the procurement of major components and initial subsystem assembly of the upper stages to support NASA missions including Tracking and Data Relay Satellites, International Solar Polar Mission, Galileo, and Venus Orbiting Imaging Radar satellite. The estimates in this area are based on the inertial upper stage and spinning solid upper stages and may be altered as a result of the reviews currently in progress.

Payload support operations - Funding in FY 1982 is required to support ongoing payload integration analysis and implementation for currently scheduled launches. NASA payloads requiring significant support in 1982 include: Galileo, International Solar Polar Mission, Long Duration Exposure Facility, Tracking and Data Relay Satellite, Space Telescope, early Spacelab missions, and Venus Orbiting Imaging Radar satellite.

	1980	1981		1982
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of Dollars)		
Shuttle Operations.	119,300	296,000	213,500	461,100

OBJECTIVES AND STATUS:

Shuttle operations funding provides for the operations and maintenance of the space transportation system. The major elements of Shuttle operations includes the following: launch, flight, landing and ground turnaround; cargo analytical integration and mission planning and operations; flight crew operations and equipment; orbiter spares and engineering support; procurement of external tanks, solid rocket boosters, main engines and propellants; ground systems operations, logistics and sustaining engineering.

CHANGES FROM 1981 BUDGET ESTIMATE:

FY 1981 funding for Shuttle operations has been reduced to reflect requirements consistent with the Shuttle flight schedule in addition to the impact of Congressional action on the FY 1981 appropriation.

BASIS OF FY 1982 BUDGET ESTIMATE:

FY 1982 funding will support the continued procurement, manufacturing, assembly and checkout of flight hardware for early operational Shuttle flights. This hardware includes solid rocket boosters, external tanks, and orbiter vehicle replenishment spare equipment. Funding will also support development of standardized Shuttle flight plans for operation of the avionics software and flight control systems. Plans and procedures for early operational missions will be developed in detail to reflect mission profiles, thermal and dynamics load requirements, and crew activities for each mission.

	1980	1981		1982
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of Dollars)		
Upper Stages Operations... ..	18,700	30,900	38,200	68,000

OBJECTIVES AND STATUS:

Upper stage operations provides funding for the procurement of the Inertial Upper Stage (IUS) and the Spinning Solid Upper Stages (SSUS). Since the recent contractor announcement of revised cost estimates for IUS development and initial production, NASA has been assessing alternatives available for planetary missions.

CHANGES FROM FY 1981 BUDGET ESTIMATES:

Upper stage operations funding reflects increases in hardware costs which had been identified based on data available prior to the recent announcement of cost increases. This requirement will be subject to adjustment based on the results of the review now in progress.

BASIS OF FY 1982 BUDGET ESTIMATE:

FY 1982 STS upper stages operations funding provides for procurement of upper stages consistent with the requirements for early operational missions with the same qualifications as the estimate for FY 1981.

	1980	1981		1982
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands	of Dollars)	
Payload Support Operations.	10,100	18,000	19,000	32,200

OBJECTIVES AND STATUS:

Payload support operations provide Shuttle payload related optional services to NASA and reimbursable users. These services include: development of unique integration hardware, spacecraft to upper stage analytical integration, and payload launch site support.

CHANGES FROM FY 1981 BUDGET ESTIMATE:

Payload support operation FY 1981 funding reflects increased analytical integration activities, but does not include results from the current IUS review.

BASIS OF FY 1982 BUDGET ESTIMATES:

Funding in FY 1982 is needed to support continuing operations related services for currently scheduled launches. NASA missions requiring support from payload support operations during this time period include: Galileo, International Solar Polar Mission, Long Duration Exposure Facility, Tracking and Data Relay Satellite, and the Venus Orbiting Imaging Radar.

EXPENDABLE
LAUNCH
VEHICLES

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1982 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE TRANSPORTATION OPERATIONS

EXPENDABLE LAUNCH VEHICLES PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1980 <u>Actual</u>	1981 <u>Budget Estimate</u> (Thousands of Dollars)	<u>Current Estimate</u>	1982 <u>Budget Estimate</u>	Page <u>No.</u>
Scout.....	5,100	2,200	900	800	RD 3-3
Centaur.	18,000	5,600	5,600	---	RD 3-4
Delta	43,100	47,900	47,900	30,400	RD 3-5
Atlas-F.....	1,200	---	---	---	RD 3-6
 Total.....	<u>67,400</u>	<u>55,700</u>	<u>54,400</u>	<u>31,200</u>	
 <u>Distribution of Program Amount by Installation:</u>					
Kennedy Space Center.....#.....	4,700	1,600	1,600	1,700	
Goddard Space Flight Center.....	38,500	45,700	45,700	28,200	
Langley Research Center.....	5,100	2,200	900	800	
Lewis Research Center.....	17,000	5,500	5,500	---	
Headquarters.....	2,100	700	700	500	
 Total.....	<u>67,400</u>	<u>55,700</u>	<u>54,400</u>	<u>31,200</u>	

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1982 ESTIMATES

OFFICE OF SPACE TRANSPORTATION OPERATIONS

EXPENDABLE LAUNCH VEHICLES PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objective of the Expendable Launch Vehicles program is to provide for the centralized procurement of launch vehicles and launch support services for NASA's automated spacecraft missions, and for other agencies and organizations utilizing these systems and services on a reimbursable basis.

NASA's expendable launch vehicle transportation systems consist of the Scout, Atlas Centaur, Delta, and Atlas-F vehicles. This family of launch vehicles has been developed to support NASA's automated spacecraft launch requirements and, on both a cooperative and a reimbursable basis, to support other government, international, and commercial agencies and organizations. The expendable launch vehicle program includes the procurement of vehicle hardware, launch services, and engineering and maintenance support, including the necessary reliability improvement of the launch vehicle, and the ancillary ground equipment.

Launches under this program are conducted from sites located at the Eastern Space and Missile Center (ESMC) formerly called the Eastern Test Range (ETR) in Florida, the Western Space and Missile Center (WSMC) formerly called Western Test Range (WTR) in California, the Wallops Flight Center in Virginia, and the San Marco Platform off the coast of Kenya, Africa.

CHANGES FROM FY 1981 BUDGET ESTIMATE:

The FY 1981 budget has been reduced by \$1.3 million in the Scout program to accommodate the overall reduction in the amount appropriated for FY 1981.

BASIS OF FY 1982 FUNDING REQUIREMENTS:

	<u>SCOUT</u>			
	<u>1980 Actual</u>	<u>1981</u>		<u>1982</u>
		<u>Budget Estimate</u>	<u>Current Estimate</u>	<u>Budget Estimate</u>
		(Thousands of Dollars)		
Scout.....	5,100	2,200	900	800

OBJECTIVES AND STATUS:

The Scout launch vehicle was initiated by NASA in 1959 with the goal of economically launching a wide variety of small scientific satellites, space probes, and re-entry experiments. The first Scout launch occurred in July 1960. In the ensuing 20 years, there have been 101 launches. Eighty-seven of these launches have been successful.

The Scout vehicle is the smallest launch vehicle employed by NASA. It is a four-stage, solid propellant launch vehicle. The vehicle is approximately 22.4 meters in length (73 feet) and the first stage booster has a diameter of 1.14 meters (3.75 feet). It is capable of placing a 180 kilogram (400 pound) payload in a 556 kilometer (300 nautical mile) orbit.

The Langley Research Center, located at Hampton, Virginia, has managed the Scout project since its inception. The prime contractor for the production, checkout, and launch of Scout is the Ling-Temco-Vought Aerospace Corporation, located in Dallas, Texas. Scout vehicles are launched from the Western Space and Missile Center, California; from Wallops Island, Virginia; and from the San Marco Platform off the African coast near Kenya.

CHANGES FROM FY 1981 BUDGET ESTIMATE:

The FY 1981 budget has been reduced by \$1.3 million in the Scout program to accomodate the overall reduction in the amount appropriated for FY 1981.

BASIS FOR FY 1982 ESTIMATE:

The funds required in FY 1982 will be used for engineering, technical support, vehicle testing and checkout, launch operations and maintenance of launch facilities and ground equipment. FY 1982 funds will provide for preparation and launch of two San Marco cooperative missions from the African San Marco launch platform. These launches will complete

NASA's use of the Scout launch vehicle by the end of 1983. However, the Scout vehicle system will be continued to support the Department of Defense, at least through 1985, on a reimbursable basis.

BASIS OF FY 1982 FUNDING REQUIREMENTS:

<u>CENTAUR</u>				
	1980 <u>Actual</u>	1981		1982 <u>Budget Estimate</u>
		<u>Budget Estimate</u> (Thousands of Dollars)	<u>Current Estimate</u>	
Centaur.....	18,000	5,600	5,600	---

OBJECTIVES AND STATUS:

This project provides for the procurement and launch of the Atlas booster stage and the Centaur upper stage. The Centaur is a high performance upper stage, which is the most powerful used by NASA for automated missions. It is being used with the Atlas booster for high energy missions, particularly planetary and synchronous orbits. The Atlas Centaur vehicle is 40 meters (131 feet) in length and has a diameter of 3.1 meters (10 feet).

BASIS OF FY 1982 ESTIMATE:

No appropriated funds are required for FY 1982 since no NASA spacecraft are planned to be launched with this vehicle system. However, this vehicle will be used for INTELSAT and DOD launches, at least through 1984, for which NASA will be reimbursed.

BASIS OF FY 1982 FUNDING REQUIREMENTS:

	<u>DELTA</u>			
	<u>1980 Actual</u>	<u>1981</u>		<u>1982 Budget Estimate</u>
		<u>Budget Estimate</u> (Thousands of Dollars)	<u>Current Estimate</u>	
<u>Delta</u>	43,100	47,900	47,900	30,400

OBJECTIVES AND STATUS:

The Delta launch vehicle is the most widely used vehicle in NASA's expendable launch vehicle family. Since its first use in 1960, this vehicle **has** been utilized in 153 launches and **has** experienced a success record of over 91 percent. It is presently operational with two and three stage configurations and a multiburn second stage capability. The first stage is an elongated Thor booster with three, six, or nine strap-on solid motors for thrust augmentation.

The second stage Delta, which provides a multiple restart capability, uses an inertial guidance system for guiding the first stage booster and the second stage Delta. The third stage utilizes the Thiokol TE-364 solid motor, which is spin stabilized. This vehicle, in its three-stage configuration, is approximately 35 meters in length (115 feet) and **has** a diameter of 2.44 meters (8 feet). It is capable of placing a 800 kilogram payload (2,000 pounds) into a synchronous transfer orbit.

BASIS OF FY 1982 BUDGET ESTIMATE:

The FY 1982 funding will be used to continue the Delta launch vehicle procurements initiated in prior years to support NASA spacecraft requirements. Funds are also required for technical and engineering support to sustain vehicle test and checkout and launch operations, and to support maintenance of launch facilities and ground equipment.

This vehicle system, planned to be operational at least until 1985, is the most utilized of our current vehicles. It is being used to support backup Shuttle user requirements, on a reimbursable basis, for launching missions for other United States government, commercial and international mission users. Development of an **uprated** second stage capable of placing a 1,232 kilogram payload (2,800 pounds) into a synchronous transfer orbit is continuing on schedule.

BASIS OF FY 1982 FUNDING REQUIREMENT:

	<u>ATLAS-F</u>			
		<u>1981</u>		<u>1982</u>
	<u>1980</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
	<u>Actual</u>	<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of Dollars)		
Atlas-F.....	1,200	---	---	---

OBJECTIVES AND STATUS:

The Atlas-F is a one and one-half stage vehicle which uses liquid oxygen and kerosene as propellants. The vehicle is a refurbished surplus intercontinental ballistic missile (ICBM) being managed by the USAF for space missions. NASA used this vehicle to launch the TIROS-N and Seasat missions successfully during 1978.

BASIS OF FY 1982 ESTIMATE:

No appropriated funds are required for FY 1982 since this vehicle system is being used only in support of the National Oceanic and Atmospheric Administration weather satellite launch on a reimbursable basis.

SPACE SCIENCE
PROGRAMS

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1982 ESTIMATES

RESEARCH AND DEVELOPMENT BUDGET PLAN FOR SPACE SCIENCE PROGRAMS

<u>Programs</u>	<u>1980 Actual</u>	<u>Budget Plan</u>		<u>1982 Budget Estimate</u>
		<u>1981</u>	<u>Current</u>	
		<u>Budget</u>	<u>Estimate</u>	
		(Thousands of Dollars)		
Physics and astronomy.	336,800	438,700	344,700	451,400
Planetary exploration.	219,900	179,600	175,600	256,100
Life sciences.	<u>43,800</u>	<u>49,700</u>	<u>42,188</u>	<u>49,200</u>
Total.	<u>600,500</u>	<u>668,000</u>	<u>562,488</u>	<u>756,700</u>

PHYSICS AND
ASTRONOMY



RESEARCH AND DEVELOPMENT

FISCAL YEAR 1982 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE

PHYSICS AND ASTRONOMY PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1980 <u>Actual</u>	1981 <u>Budget Estimate</u> (Thousands of Dollars)	1981 <u>Current Estimate</u>	1982 <u>Budget Estimate</u>	Page <u>No.</u>
Space telescope (ST) development	112.700	119.300	119.300	119.500	RD 4-8
International solar polar mission (ISPM) development	47.900	39.600	39.600	58.000	RD 4-10
Gamma ray observatory (GRO) development	---	19.100	17.600	52.000	RD 4-12
Shuttle/Spacelab payload development and mission management	40.600	29.100	27.400	51.800	RD 4-14
Explorer development	32.300	33.000	33.000	36.600	RD 4-16
Mission operations and data analysis (MO&DA)	37.100	38.900	38.900	53.500	RD 4-18
Research and analysis (R&A)	33.774	36.700	38.000	42.500	RD 4-21
Suborbital program	27.226	30.900	30.900	37.500	RD 4-26
High energy astronomy observatories (HEAO) development	2,100	---	---	---	---
Solar maximum mission (SMM) development	3,100	---	---	---	---
Total	<u>336,800</u>	<u>346.600</u>	<u>344.700</u>	<u>451.400</u>	

Distribution of Program Amount by Installation:

Johnson Space Center	146	2.415	1.680	4.594
Kennedy Space Center	2.796	2.358	4.877	3.503
Marshall Space Flight Center	154.186	162.401	158,331	175.872
Goddard Space Flight Center	79.637	91.245	83.687	155.454
Jet Propulsion Laboratory	51.027	39.292	48.616	55.701
Wallops Flight Center	5.816	6.874	7.613	9.372
Ames Research Center	14.673	8.368	12.714	8.913
Langley Research Center	675	37	37	13
Headquarters	27.844	33.610	27.145	37.978
Total	<u>336,800</u>	<u>346,600</u>	<u>344,700</u>	<u>451.400</u>

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1982 ESTIMATES

OFFICE OF SPACE SCIENCE

PHYSICS AND ASTRONOMY PROGRAM

LAUNCH SCHEDULE

<u>PROJECT</u>	<u>MISSION</u>	<u>CALENDAR YEAR</u>
International Solar Polar Mission	ISPM	1985
Space Telescope	ST	1985
Gamma Ray Observatory	GRO	1986
Space Shuttle Orbital Flight Test Payloads	OSTA-1	1981
	OSS-1	1982
Spacelab	Spacelab 1	1983
	Spacelab 2	1983
(NASA Shuttle/Spacelab Payloads will build to a flight rate of approximately 5 equivalent Spacelab missions per year by 1985).		
Explorers :		
	Dynamics Explorer	1981
	San Marco-D/Low Orbit	1982
	San Marco-D/Multistationary	1983
	Solar Mesosphere Explorer	1981
	Infrared Astronomical Satellite	1982
	Cosmic Ray Isotope Experiment	1981

<u>PROJECT</u>	<u>MISSION</u>	<u>CALENDAR YEAR</u>
	Active Magnetospheric Particle Tracer Explorer	1984
	Extreme Ultraviolet Explorer	1985
	Cosmic Background Explorer	1986
Suborbital Programs :		
Sounding Rockets		About 60 launches per year
Balloon Flights		About 20 launches per year
Airborne		About 80 flights per year with C-141 Airborne Observatory

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1982 ESTIMATES

OFFICE OF SPACE SCIENCE

PHYSICS AND ASTRONOMY PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The major objective of the Physics and Astronomy program is to increase our knowledge and understanding of the solar-terrestrial space environment and the origin, evolution, structure, and composition of the universe, including the Sun, the stars, and the other celestial bodies. Space-based research is being conducted to investigate the physics, chemistry and the transport processes occurring in the Earth's magnetosphere, ionosphere, and atmosphere, and the responses of the transport processes to solar phenomena and variability; the structure and dynamics of the Sun and its long- and short-term variations; cosmic ray, x-ray, ultraviolet, optical, infrared, and radio emissions from stars, interstellar gas and dust, pulsars, neutron stars, quasars, blackholes, and other celestial sources; and the laws governing the interactions and processes occurring in the universe. Many of the phenomena being investigated are not detectable from ground-based observatories because of the obscuring or distorting effects of the Earth's atmosphere.

To achieve the objectives of the Physics and Astronomy program, NASA employs theoretical and laboratory research; aircraft, balloon, and sounding rocket flights; Shuttle/Spacelab flights; and free-flying spacecraft. Research teams involved in the Physics and Astronomy program are located at universities, industrial laboratories, NASA field centers, and other government laboratories.

The scientific information obtained and the technology developed in this program are made available to the scientific and technical communities for application to and the advancement of scientific knowledge, education, and technology.

The Physics and Astronomy missions undertaken to date have been extraordinarily successful. The High Energy Astronomy Observatories (HEAO's) are making a major contribution to our understanding of the high energy processes and of the distribution and characteristics of x-ray emitting objects. The Solar Maximum Mission (SMM) has answered several of the basic questions about the processes which occur in solar flares, and has detected day-to-day changes in the total amount of light and heat emitted by the Sun. Explorer satellites, a program involving a series of relatively low cost missions whose origin dates back to the beginning of our country's space program, continue to make major discoveries about celestial phenomena, as well as the nature of the solar terrestrial interactions and their effect on the near-Earth environment. For example, the International Ultraviolet Explorer has recently provided evidence that stellar magnetic fields and rotation probably combine to cause the tremendous levels of solar-like activity we detect in many classes of cool binary stars. This type of information may lead to a better understanding of the Sun's variability. The Atmosphere Explorer (AE) has made a major breakthrough in our understanding of the processes by which solar ultraviolet

radiations are absorbed by the atmosphere and produce the ionosphere, and the balance between the chemical reactions that produce large seasonal latitudinal and solar cycle variations at the magnetosphere boundaries. Energy transfer processes by magnetic warping from the solar wind magnetic field through the magnetopause into the magnetosphere have been observed. The AE has also found strong electrodynamic processes that send atmospheric constituents far out into the magnetosphere and solar wind constituents down into the atmosphere, and has examined the acceleration processes by which solar wind particles are hurled back toward the Sun with high energies. These acceleration processes have clear implications for astrophysics and laboratory energy generators. The explorer program plays a key role in development of technology and serves as a further test opportunity for the techniques necessary for later, more complex observatories.

Major accomplishments during FY 1980 included the launch, on February 14, of the Solar Maximum Mission (SMM). This spacecraft has now observed over a thousand flares since launch, using instruments which observed wavelengths ranging from the highest energy gamma rays down to visible light. Major scientific results from SMM include the discovery that the x-rays given off during solar flares are produced by beams of high speed electrons which shower down on the Sun's surface when a flare goes off, and the measurement of the reduction in the total amount of light emitted by the Sun due to the darkening of sunspots.

The second of the High Energy Astronomy Observatories (HEAO) series, HEAO-2, is currently carrying out a preliminary survey of the sky for gamma ray lines and is measuring the composition of cosmic ray particles. Significant scientific results obtained from the HEAO missions to date include the discovery by HEAO-1 of more than 1,000 new x-ray sources, the demonstration by HEAO-2 that a much wider variety of stars emit x-rays in greater quantities than previously predicted, and new information provided by HEAO-3 has provided new information on the detailed composition of cosmic rays in the iron, nickel, and cobalt group of elements. Several sounding rocket payloads of specialized x-ray instruments have been flown on correlative flights during the operation of the Solar Maximum Mission. Major progress was also made in the development of experiments and other flight equipment for future physics and astronomy missions. The Space Telescope, the International Solar Polar Mission, the Dynamics Explorers, the Infrared Astronomical Satellite, and the Solar Mesosphere Explorer are in various stages of flight development. The development of the instruments which will be flown on one of the Shuttle orbital flight tests, OSS-1, progressed in FY 1980 with most of the instruments completed and placed into storage until shortly before the launch. The experiments on OSS-1 will gather solar physics data, evaluate the ambient and induced Shuttle environment, and provide data on payload thermal control technology. Significant progress has also been made in the preparation of the Spacelab 1 and 2 missions, which are operational demonstration flights of Spacelab hardware that the European Space Agency developed. During FY 1980, definition work was carried out on the initial follow-on Shuttle/Spacelab physics and astronomy experiments, some of which will fly as early as 1984. The Chemical Release Module development contract was let in FY 1980, and definition of the Shuttle Infrared Telescope Facility is continuing. The Solar Optical Telescope development will be initiated in FY 1981.

In FY 1981, the Gamma Ray Observatory instrument and spacecraft design and development will be initiated, leading to an early 1986 launch. The Gamma Ray Observatory is a comprehensive mission designed to study the full sky over the total range of the gamma ray energies. Gamma rays are the most energetic electromagnetic radiation known. It is believed that their study will reveal details of fundamental cosmic nuclear and high energy processes, especially those occurring in active galaxies and quasars as well as in supernovae.

In FY 1981, development activities will continue on the Space Telescope which will allow research at the forefront of optical and ultraviolet astronomy for decades. Work will also continue on the International Solar Polar Mission which will be the first mission to explore the three-dimensional space around the Sun. The Dynamics Explorer, which will investigate the interaction of the Earth's magnetosphere and ionosphere, is in final integration and test leading to a launch in 1981. Development will continue on the Infrared Astronomical Satellite (IRAS), a cooperative mission with the Netherlands and the United Kingdom, leading to a launch in 1982. The IRAS will perform an all-sky survey of infrared sources, and will study in more detail, selected galactic and extragalactic sources. Development work on the San Marco-D missions, which are cooperative missions with Italy, will be continued, leading to launches in 1982 and 1983. Development will also be continued on the Cosmic Ray Isotope Experiment, which will be launched on a Department of Defense satellite in 1981, and on the Solar Mesosphere Explorer which will also be launched in 1981. The Solar Mesosphere Explorer will determine solar ultraviolet flux, and study corresponding changes occurring in ozone and related chemistry as a result of the ultraviolet radiation. Development activity will be initiated in late FY 1981 on the Active Magnetospheric Particle Tracer Explorer (AMPTE), a cooperative program with the Federal Republic of Germany, which will study the solar wind at the subsolar point and identify particle entry windows, entry mechanisms, energization processes and transport processes into the magnetosphere.

CHANGES FROM FY 1981 BUDGET ESTIMATE:

The current estimate for the FY 1981 Physics and Astronomy program is \$1.9 million below the budget estimate, as a net result of specific adjustments made to the program by the Congress, together with the application to this program of a portion of the general Congressional reduction to the appropriations request. Decreases of \$1.5 million in the Gamma Ray Observatory (made possible due to the delayed start of development caused by Continuing Resolution restrictions) and \$1.7 million in Spacelab payload development and mission management were offset by an increase of \$1.3 million in research and analysis.

BASIS OF FY 1982 ESTIMATES:

FY 1982 funding will provide for the launch of the space science payload (OSS-1) which is to be flown on a Shuttle orbital flight test, and launch of the Infrared Astronomical Satellite as well as the first of the San Marco-D missions. Development work will continue on the Space Telescope, the International Solar Polar Mission, the Gamma Ray Observatory, and the Active Magnetospheric Particle Tracer Explorer (AMPTE). FY 1982 funding will support the continued development of the Chemical Release Module and the Solar Optical Telescope.

In N 1982, work will continue on the mission management efforts for all NASA Spacelab payloads. The FY 1982 funds will provide for the continued instrument development and mission management for Spacelabs 1 and 2, and for instrument development and mission management activities for future Spacelab missions.

FY 1982 mission operations and data analysis activities will focus on the operation and analysis of data from satellites which are producing valuable scientific data. These satellites include the Solar Maximum Mission, HEAO-3, the International Ultraviolet Explorer, the International Sun Earth Explorers, and the Interplanetary Monitoring Platform (IMP-J). Mission operations and data analysis will also be underway for the Dynamics Explorers and for the Solar Mesosphere Explorer (SME). In addition, FY 1982 funding will support the analysis of the data acquired by the highly successful OAO-3, SAS-C, and HEAO-1 and -2 as well as preparations for science operations for the Space Telescope.

The FY 1982 suborbital program will provide for continuation of sounding rocket activity and continuing scientific investigation through balloon and aircraft flights.

Research and analysis FY 1982 funding will support a broad range of efforts to provide the research and technology base required for well conceived and defined future programs. In the supporting research and technology program, tasks critical to maintaining a firm scientific base for physics and astronomy will continue. In the area of advanced technology development, design and definition will be carried out for potential future missions, including Shuttle/Spacelab payloads and free-flying spacecraft. The data analysis activity will include operation of the National Space Science Data Center (NSSDC) and general data analysis activities.

BASIS OF FY 1982 FUNDING REQUIREMENT:

<u>SPACE TELESCOPE (ST DEVELOPMENT)</u>				
	1980	1981		1982
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of Dollars)		
Spacecraft	76,900	95,100	85,000	83,500
Experiments.....	<u>35,800</u>	<u>24,200</u>	<u>34,300</u>	<u>36,000</u>
Total.	<u>112,700</u>	<u>119,300</u>	<u>119,300</u>	<u>119,500</u>
Mission operations and data analysis..	(1,800)	(6,700)	(6,700)	(15,200)
Space transportation system operations..	(300)	(3,200)	(500)	(3,000)

OBJECTIVES AND STATUS:

The Space Telescope will make a major contribution to understanding the stars and galaxies, and the nature and behavior of the gas and dust between them; and the broad question of the origin and scale of the universe. Operating in space above the atmospheric veil surrounding the Earth, the Space Telescope will increase by several hundredfold the volume of space accessible for observations. With its significant improvements in resolution and precision in light sensitivity and in wavelength coverage, the Space Telescope will permit scientists to conduct investigations that could never be carried out using ground-based observatories due to the obscuring and distorting effects of the Earth's atmosphere.

The Space Telescope will enhance the ability of astronomers to study radiation in the visible and ultraviolet regions of the spectrum. It will be more sensitive than ground-based telescopes and will record greater detail about the objects under study. It will make possible observation of objects so remote that the light will have taken many billions of years to reach us. As a result, we will be able to look far into the distant past of our universe. The Space Telescope will also contribute significantly to the study of the early stages of stars and the formation of solar systems as well as to the observation of such highly evolved objects as supernova remnants and white dwarf stars. With the Space Telescope, we may be able to determine the nature of quasars, and the processes by which they emit such enormous amounts of energy, and it may also be possible to determine whether some nearby stars have planetary systems.

The Space Telescope will be an automated observatory, delivered into orbit by the Shuttle. Data from its scientific instruments will be transmitted to Earth via the tracking and data relay satellite system. The Space Telescope will differ from existing automated satellites in that its design will permit in-orbit maintenance, repair, and retrieval by the Space Shuttle for return to Earth, refurbishment and reuse.

A detailed schedule and cost review has been conducted on the Space Telescope project, and based on the results of this review, a new launch date and estimate of cost through completion has been established. The revised launch date for the Space Telescope is the first half of 1985, as opposed to late 1983 which was the original launch date. The revised estimate for the cost through completion for the Space Telescope development is \$700-\$750 million in FY 1982 dollars as opposed to \$540-\$595 million which was the original estimate in terms of FY 1982 dollars.

During FY 1980, continued progress was made in the design and development of the Space Telescope. The primary mirror blanks are in the final stages of polishing. One primary mirror is being polished by a new computer-controlled polishing machine. This technique was demonstrated by polishing a 60-inch mirror to Space Telescope specifications. The backup to the flight primary mirror is being polished, using traditional manually controlled polishing machines. The optical telescope assembly contractor completed design activities leading to the critical design reviews (CDRs) in the last half of FY 1980. Manufacturing was initiated following these reviews. The CDRs for three of the five science instruments were conducted in FY 1980. The fourth CDR was completed in early FY 1981 and the final instrument CDR is scheduled for the spring of 1981. In addition, a CDR was completed on the system for the control and data handling for the scientific instruments. The metering truss assembly which separates the primary and secondary mirrors has been completed. A pointing control system development test, which included preliminary software, flight hardware, and simulators, was completed by the support systems module contractor.

FY 1981 activities continue to support detailed design, development, and manufacture of the optical telescope assembly, the support systems module, and the scientific instruments. Polishing of the flight primary mirror will be completed in 1981. A systems interface review for the support systems module, optical telescope assembly, and the scientific instruments is scheduled for mid-1981.

CHANGES FROM FY 1981 BUDGET ESTIMATE:

The total FY 1981 funding requirement for the Space Telescope development is unchanged. However, there is a redistribution between the spacecraft and experiments due to a rephasing of the program consistent with a 1985 launch date.

BASIS OF FY 1982 ESTIMATE:

FY 1982 funding will support the fabrication and assembly activities of the optical telescope assembly (OTA), the scientific instruments and the support systems module. The fabrication and assembly of the scientific instruments is scheduled to be completed in early 1983, with verification testing to follow. The primary mirror of the optical telescope assembly is scheduled to be completed, and assembly of the OTA subsystems is scheduled to continue in FY 1982. The critical design review of the support systems module will be completed in FY 1982.

BASIS OF FY 1982 FUNDING REQUIREMENTS:

	<u>INTERNATIONAL AR OLAR MISSION ISPM) DEVELOPMENT</u>			
	1980	1981		1982
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of Dollars)		
Spacecraft.. .. .	27,700	26,300	21,200	47,734
Experiments.....	19,000	12,000	17,000	7,830
Ground operations.	<u>1,200</u>	<u>1,300</u>	<u>1,400</u>	<u>2,436</u>
Total.....	<u>47,900</u>	<u>39,600</u>	<u>39,600</u>	<u>58,000</u>
Space transportation system operations.. .. .	(2,400)	(3,200)	(10,3 00)	(21,3 00)

OBJECTIVES AND STATUS:

The International Solar Polar Mission is a joint NASA and European Space Agency (ESA) mission designed to obtain the first view of the solar system from a new perspective—a view from far above and far below the plane in which the planets orbit the Sun's equator. The two spacecraft will aid in the study of the relationship between the Sun and its magnetic field and particle emissions (solar wind and cosmic rays) as a function of solar latitude, and hence may allow us to gain insight into the possible effects of solar activity on the Earth's weather and climate.

NASA and ESA will each provide one spacecraft of approximately equal and complementary capabilities. Science experiments have been assigned to each of the two spacecraft by a joint selection committee. Launch, tracking and data acquisition, and mission operations will be carried out by NASA, with ESA participation.

Employing a concept that exploits the gravitational pull of Jupiter, the launch of the ISPM is scheduled for 1985. The NASA and ESA spacecraft will be launched by the space transportation system on a trajectory to Jupiter. The gravitational force of Jupiter will be used to swing the two spacecraft on mirror image courses (north and south) back around the Sun, to solar latitudes as high as 80° .

The ISPM project underwent some descoping in mid-1980 to contain the amount of cost growth due to the change in launch date from 1983 to 1985. This change ~~was~~ a result of the FY 1981 Budget Admendment. The science descoping should not, however, affect the science return of the mission in any major way as the descoping was basically confined to redundant science. Negotiations have been completed with the ISPM contractors for the 1985 launch.

CHANGE FROM FY 1981 BUDGET ESTIMATE:

The total FY 1981 funding requirement for the International Solar Polar Mission development is unchanged. However there is a redistribution among spacecraft, experiments and ground operations due to further definition of the requirements resulting from the launch date being changed from 1983 to 1985.

BASIS OF FY 1982 ESTIMATE:

During FY 1982, the spacecraft development activities will continue. They will focus on preparation for the critical design review (CDR) in early FY 1983. During FY 1982, most experiment flight hardware production will be initiated. In addition, full-scale development activities on the ISPM mission operations system design will begin with the preliminary design review scheduled for mid-1983 and the CDR scheduled for late 1983.

BASIS OF FY 1982 FUNDING REQUIREMENTS:

GAMMA RAY OBSERVATORY (GRO) DEVELOPMENT

		1980 <u>Actual</u>	1981		1982
			<u>Budget</u> <u>Estimate</u> (Thousands of Dollars)	<u>Current</u> <u>Estimate</u>	<u>Budget</u> <u>Estimate</u>
Spacecraft.....	---	2,830	2,700	30,000
Experiments.....	---	16,100	14,800	20,600
Ground operations.....	---	<u>170</u>	<u>100</u>	<u>1,400</u>
Total.....		---	<u>19,100</u>	<u>17,600</u>	<u>52,000</u>

OBJECTIVES AND STATUS:

The objective of the Gamma Ray Observatory (GRO) mission is to measure gamma ray radiation from the universe and, thus, to explore the fundamental physical processes powering it. Certain celestial phenomena are accessible only at gamma ray energies. The observational objectives of GRO are: to search for direct evidence of the synthesis of the chemical elements; to observe high energy astrophysical processes occurring in supernovae, neutron stars and black holes; to locate gamma ray burst sources; to measure the diffuse gamma ray radiation for cosmological evidence of its origin; and to search for unique gamma ray emitting objects.

Gamma rays represent **one** of the last frontiers of the electromagnetic spectrum to be explored because the required technology has only recently been developed. The low flux levels of gamma ray quanta, and the high background they produce through their interaction with the Earth's atmosphere, coupled with the demand for better spectral, spatial, and temporal resolution of source features, combine to require that large gamma ray instruments be flown in space for a prolonged period. Gamma rays provide unique information on the most astronomically intriguing objects yet discovered, including quasars, neutron stars, and black holes. Astronomy is now to the point where our understanding of these objects is being seriously impaired by lack of data in the gamma ray region of the spectrum. Comprehensive research in gamma ray astronomy has, therefore, consistently been given high priority by the science community.

The GRO will be launched by the Space Shuttle. The spacecraft is designed to accommodate several gamma ray instruments. It is planned that the majority of the instruments will have their principal axes pointing in the same direction, and the spacecraft will point these instruments in a fixed direction in space for long periods of time (hours to

weeks). The accessibility of different regions of space at any given time will only be limited by solar array pointing and seasonal constraints.

During FY 1980, a competitive procurement led to the selection of two Phase B study contractors, who completed parallel, independent mission concept studies. Definition of the scientific instruments also was completed in FY 1980. FY 1981 activities include the selection of the mission systems contractor, initiation of spacecraft design and development, confirmation of the scientific instruments, and initiation of the development contracts for the instruments. The design and development was originally planned to be initiated in early FY 1981; however, these activities have been delayed by approximately six months primarily due to the Continuing Resolution restriction on implementing these efforts pending final action on the appropriation request for FY 1981. The effect of this delay on the total cost and schedule is yet to be determined.

CHANGES FROM FY 1981 BUDGET ESTIMATES:

The \$1.5 million decrease from the FY 1981 budget estimate is due to the Congressional general reduction in the overall appropriation request. This reduction in GRO funding is possible because of the delay in the initiation of the GRO activities from early to mid-FY 1981 for the reason indicated above.

BASIS FOR FY 1982 ESTIMATES:

The FY 1982 funding is required to continue the GRO design and development activities which were initiated in FY 1981. The mission system contractor will finalize electrical and mechanical interfaces with both the scientific instruments and the Space Shuttle. Drawings for fabrication will be released and software specifications for the integration efforts will be completed.

BASIS OF FY 1982 FUNDING REQUIREMENTS:**SHUTTLE/SPACELAB SCIENCE PAYLOAD DEVELOPMENT AND MISSION MANAGEMENT**

	1980 <u>Actual</u>	<u>Budget</u> <u>Estimate</u> (Thousands of Dollars)	<u>Current</u> <u>Estimate</u> (Thousands of Dollars)	1982 <u>Budget</u> <u>Estimate</u>
Payload development and mission management	40,600	29,100	27,400	51,800
Space transportation system operations.. ..	(800)	(13,000)	(8,800)	(25,700)

OBJECTIVES AND STATUS:

The objectives of Shuttle/Spacelab science payload development and mission management are to acquire new knowledge in the disciplines of physics and astronomy and to manage the mission planning and execution of the complete NASA Spacelab payload program. The funding provides for the development of all physics and astronomy Spacelab experiments, the system management and engineering development of the flight equipment and software, the payload specialist support, the physical integration of the payload with the Spacelab system, the operation of the payload during flight, the dissemination of data to experimenters and the analysis of physics and astronomy flight data.

Instruments to be flown on three missions primarily dedicated to physics and astronomy science are now under development. The development of instruments which will be flown on the Shuttle orbital flight tests, OSS-1, is nearly complete. The OSS-1 mission will have six instruments mounted on a pallet that will gather solar physics data, evaluate the Shuttle environment, and provide data on thermal control technology. Integration and test of the OSS-1 payload is now nearing completion. Spacelab 1, consisting of a pressurized Spacelab module and a pallet, will be flown in 1983. The primary objective of Spacelab 1 is to demonstrate the capabilities of the Spacelab system, while the secondary objective is to obtain multidisciplinary scientific data with emphasis on atmospheric and space plasma physics. In N 1981, the Spacelab 1 instrument development mission management tasks will essentially be completed. Spacelab 2, an all-pallet configuration, will fly in 1983. The primary objective of Spacelab 2 is to verify the Spacelab igloo and pallet systems. The secondary objective is to obtain scientific data with emphasis on astrophysics and solar physics. The instrument pointing system, developed by the European Space Agency, will be used for the first time on the Spacelab 2 mission. During N 1981, Spacelab 2 mission management activities and instrument development will continue.

Several physics and astronomy instruments are under development for flights on the Shuttle/Spacelab in 1984 and subsequent years. Two general types of instruments are under development; principal investigator, and multiuser instruments. Principal investigator instruments are for a specific scientific investigation by a single investigator

who ~~may~~ have co investigators. Multiuser instruments have a broad scientific capability, can accommodate a number of **principal** investigator-furnished focal plane or ancillary instruments, and have a large user community. The Chemical Release Module **is** a multiuser instrument now under development. The Chemical Release Module will be used to trace the atmospheric motions of neutral constituents to ~~map~~ magnetic and electric fields, to display plasma instabilities, and to study (using test particles) particle behavior. In **1981**, the focal plane instruments for the first flight of the Solar Optical Telescope, which is now in the definition phase, will be selected from responses to an announcement of opportunity. A third multiuser instrument which is under definition is the Shuttle Infrared Telescope Facility which **will** conduct high resolution studies of selected celestial infrared objects and will provide valuable insight into many questions of modern astrophysics including the early stages of star formation and the later stages of star evolution, the unusually high energy output of the nuclei of certain galaxies and quasars and the early evolution of galaxies and the universe. Definition and development schedules of physics and astronomy instruments are phased to form scientifically focused payloads. Instruments, both those that are now being developed for OSS-1, Spacelab 1, and Spacelab 2 as well as the principal investigator and multiuser instruments, will be reused on future Shuttle/Spacelab missions thereby significantly increasing the scientific value of the original investment .

In **FY 1981**, mission management of all **NASA** Shuttle/Spacelab missions will continue. Mission management for the non-physics and astronomy missions involves all the Spacelab payload functions except instrument or experiment development and data analysis. Prominent among the mission activities outside the physics and astronomy disciplines are three space applications and technology missions; (**OSTA-1, OSTA-2, OAST-1**), Spacelab 3, and mission management for the life sciences program.

Part of Shuttle/Spacelab science payload development and mission management activities involves the development of several systems necessary for the optimum use of the Shuttle/Spacelab system by all users. At the Kennedy Space Center a system is being implemented to assemble experiments with Spacelab hardware to form an actual mission payload and subsequently to test the integrated system. An annular suspension pointing system, will significantly enhance the quality of scientific data from mounted instruments and will allow more efficient use of the Spacelab provided instrument support systems. This pointing system can be used for both principal investigator and multiuser instruments.

CHANGES FROM FY 1981 BUDGET ESTIMATE:

The **\$1.7 million** decrease from the **FY 1981** budget estimate is due to the Congressional general reduction in overall appropriation request. This reduction coupled, with the reduction in the **N 1981** Budget Amendment, will further delay the planning and eventual use of the Shuttle/Spacelab as a science data acquisition capability.

BASIS OF FY 1982 ESTIMATE:

The **FY 1982** funding is required for final preparations for the flight of **OSS-1** which will be flown on one of the

Shuttle orbital flight tests and the data analysis from the mission. In addition, final preparation for the first use of the Shuttle/Spacelab system will be accomplished in FY 1982, and preparation for the initial science, applications, and technology payloads to be flown on the Shuttle/Spacelab will be continued. Spacelab 1 will begin final integration and testing at the Kennedy Space Center. Spacelab 2 will complete mission activities leading to integration and test, and mission management activities for the applications and technology missions will continue. Several principal investigator instruments will be in development leading to first use in 1984, and development will continue on the Chemical Release Module and on the Solar Optical Telescope.

BASIS OF FY 1982 FUNDING REQUIREMENTS:

EXPLORER DEVELOPMENT

	1980 <u>Actual</u>	1981 <u>Budget</u> <u>Current</u> <u>Estimate</u> <u>Estimate</u> (Thousands of Dollars)		1982 <u>Budget</u> <u>Estimate</u>
Dynamics explorer (DE)	11,806	12,600	12,600	---
Solar mesosphere explorer (SME)	6,788	4,078	3,800	---
Infrared astronomical satellite (IRAS)	12,051	5,066	13,500	6,600
Active magnetospheric particle tracer explorer (AMPTE)	---	6,600	1,200	15,200
Other explorers	<u>1,655</u>	<u>4,656</u>	<u>1,900</u>	<u>14,800</u>
Total	<u>32,300</u>	<u>33,000</u>	<u>33,000</u>	<u>36,600</u>
Mission operations and data analysis (MO&DA)	(14,752)	(14,783)	(14,783)	(23,100)
Scout and Delta (expendable launch vehicles program)	(12,300)	(---)	(5,500)	(5,000)
Space transportation system operations	(---)	(4,200)	(---)	(---)

OBJECTIVES AND STATUS:

The explorer program provides the principal means of conducting astronomical studies and long-term investigations of solar physics and of the near-Earth interplanetary environment having limited, specific objectives and not requiring major observatories.

Included in the present program are missions to study atmospheric and magnetospheric physics; the several magnetospheric boundaries; interplanetary phenomena ; and x-ray, ultraviolet, and infrared astronomy.

Studies are conducted to define future high priority science explorer missions. NASA engages in cooperative missions with other Federal agencies and other nations whenever such cooperation will assist in achieving NASA objectives.

Solar terrestrial and atmospheric explorers provide the means for conducting studies of the Earth's near-space environment. The program requires a wide variety of satellites in orbits extending from the very lowest reaches of the upper atmosphere, to the interplanetary medium beyond the Earth's magnetosphere. The Solar Terrestrial program is in a transition from the early discovery and mapping phase conducted over the past decade to a phase in which specific problems are being investigated in more depth, frequently using simultaneous multipoint measurements. Efforts underway include completion of development activity in FY 1981 for three explorers: the Solar Mesosphere Explorer (SME), the Dynamics Explorer (DE), and the first of the two San Marco-D missions. Development activity is continuing on the second San Marco -D mission, and it is now planned that development activities will be initiated on the Active Magnetospheric Particle Tracer Explorer (AMPTE) during FY 1981. The SME is designed to investigate the relationship of solar ultraviolet flux to processes in the upper atmosphere including the production of ozone. DE will provide data on the strong interactive processes coupling the hot convecting plasmas of the magnetosphere and the cooler plasmas and gases of the Earth's ionosphere and upper atmosphere. The San Marco-D missions, a cooperative project with Italy, will include a group of experiments to study the relationship between solar activity and the Earth's meteorological phenomena. AMPTE, a planned cooperative program with the Federal Republic of Germany, will use two spacecraft to study the solar wind at the sub-solar point and to identify particle entry windows, energization processes and transport processes into the magnetosphere.

Astrophysics explorers have been instrumental in conducting the first astronomical sky surveys in the gamma ray, x-ray, ultraviolet, and infrared and low frequency radio regions of the electromagnetic spectrum. A major effort underway in FY 1981 is the completion of experiment fabrication and testing and satellite integration activities on the Infrared Astronomical Satellite (IRAS), which is scheduled to be launched in 1982.

CHANGES FROM FY 1981 BUDGET ESTIMATE:

The total FY 1981 Explorer funding requirement is unchanged. However, there have been changes made to all of the respective explorers except the Dynamics Explorer. The Infrared Astronomical Satellite experienced a number of technical difficulties which have resulted in an increased funding requirement in the areas of cryogenic system fabrication, mirror polishing, and focal plane detector systems development. The other elements of the total explorer line have been decreased to accommodate the additional funding needed for IRAS. However, the decrease to the Solar Mesosphere Explorer is due to better than expected development progress. The decrease in the planned initial funding for AMPTE will delay the scheduled start of the project from early FY 1981 to late 1981, and the resources planned for initiating new explorer projects have been reduced in FY 1981.

BASIS OF FY 1982 ESTIMATE:

FY 1982 funding will provide for completion of development activity, launch, and initial orbital operations for the Infrared Astronomical Satellite. The first of the San Marco-D missions will be launched in 1982 and development activity for the AMPTE mission will be continued. In addition, development activities for the Cosmic Background Explorer (COBE) and the Extreme Ultraviolet Explorer (EUVE) may be initiated. FY 1982 funding also will provide for design and definition studies for future candidate missions including the X-Ray Time Explorer (XTE) and the Solar Corona Explorer (SCE).

BASIS OF FY 1982 FUNDING REQUIREMENTS:MISSION OPERATIONS AND DATA ANALYSIS

	1980	1981		1982
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of Dollars)		
High energy astronomy observatory (HEAO)				
basic mission.....	5,236	128	128	---
HEAO extended mission.....	8,521	10,606	10,606	8,800
Solar maximum mission (SMM) basic mission.....	4,500	3,400	3,400	600
SMM extended mission.....	---	1,600	1,600	5,000
Space telescope (ST).....	1,800	6,700	6,700	15,200
Explorers.....	14,752	14,783	14,783	23,100
Orbiting astronomical observatory,	2,291	1,683	1,683	800
Total.....	<u>37,100</u>	<u>38,900</u>	<u>38,900</u>	<u>53,500</u>

OBJECTIVES AND STATUS:

The purpose of the mission operations and data analysis effort is to conduct operations and to analyze data from the physics and astronomy satellites after launch. This program also supports the continued operation of a number of spacecraft after their originally planned objectives have been achieved for purposes of conducting specific investigations that have continuing high scientific significance. The bulk of funding supports the data analysis activities of the many investigators at universities and other research organizations associated with astrophysics and solar terrestrial operational satellite projects. Actual satellite operations, including operation control centers and

related data reduction and engineering support activities are typically carried out under a variety of mission support or center support contracts.

The Solar Maximum Mission (SMM) was launched on February 14, 1980, to make detailed observations of solar flare processes during the current period of maximum solar activity (1979-1983). Sunspot numbers have been very high since the launch of SMM and the spacecraft has seen over 1,000 flares of all sizes. The SMM instruments will permit detailed coherent investigation of flare—ccelerated electrons and nucleons, flare plasmas over a wide range of temperatures, coronal disturbances resulting from flares, and the total amount of light and heat emitted by the Sun.

In addition, coordinated observations by SMM and the currently operational International Sun-Earth Explorers (ISEE) are permitting studies of the sources of specific solar wind disturbances and their effects on the Earth's magnetosphere. Among the primary results from SMM are the first observations of a solar flare as seen in very high energy x-rays, the discovery that flares produce ultraviolet emissions by bombardment of the Sun's surface by high speed electrons, and the observation of high speed protons produced in rapid bursts which are delayed by a few seconds with respect to very similar bursts of high speed electrons.

The High Energy Observatories (HEAO-1, 2, and 3) have provided new and complementary data on a wide variety of cosmic x-ray sources. HEAO-1 completed a highly successful mission of mapping the entire x-ray sky with unprecedented sensitivity before reentering the Earth's atmosphere in March 1979. Among the primary results were the discovery of more than one thousand new x-ray sources; the determination of precise locations of many sources allowing optical identifications; the establishment of whole new classes of x-ray emitting objects; the detection of line emission from hot, highly ionized iron in neutron star binaries, supernova remnants, and clusters of galaxies; the discovery of x-ray emission from active stars; and the measurement of the spectrum of the diffuse x-ray sky background which is suggestive of an origin in a hot, tenuous gas at a temperature of 400 million degrees Kelvin.

HEAO-2 completed its second year of operation in November 1980 and has yielded a series of impressive results. For example, proceeding from the closest to the most distant objects, HEAO-2 has demonstrated that almost all types of stars emit x-rays in greater quantities than previously predicted. Similarly, HEAO-2 observations of supernova remnants have had a profound impact on theories of the processes of supernova explosions and neutron star formation. Beyond our own galaxy, HEAO-2 has mapped the Milky Way's nearest neighbor galaxies, and has detected the most distant quasars observed with optical telescopes. HEAO-2 operations will continue until propellant depletion, which is estimated to occur by mid-1981.

HEAO-3 was launched in September 1979. All instruments are returning excellent scientific data. The galactic plane has been extensively scanned with the gamma ray spectrometer, and preliminary analysis of the data shows the detection of matter - antimatter annihilation line radiation from the direction of the center of our galaxy, suggesting the presence of a massive black hole. The cosmic ray instruments have provided new information on the detailed composition of cosmic rays in the group of elements including iron, nickel and cobalt.

In addition to the ~~normal~~ support required for mission operations, the Space Telescope program presents several unique aspects which must be provided well in advance of launch. The Space Telescope is designed for operation for more than a decade, based on in-orbit maintenance, recovery, refurbishment, and relaunch and in-orbit changeout of the scientific instruments at the focal plane. During the operational period, it will be used primarily by observers scheduled on the basis of proposals submitted in response to periodic solicitations. NASA has determined that the most efficient and scientifically satisfactory approach to science operations will involve establishment of an independent Science Institute which will operate under a long-term contract with NASA. While NASA will retain operational responsibilities for the observatory, the Institute will implement NASA policies in the areas of planning, management, and scheduling of the scientific operations of the telescope.

Several explorer spacecraft remain operational and are providing valuable data. The International Ultraviolet Explorer (IUE) and International Sun-Earth Explorers (ISEE) continue to perform well, with very productive guest investigator programs. The last Atmospheric Explorer (AE-E), launched in 1975, is still functioning well and is providing insight into thermospheric and atmospheric variations not otherwise obtainable. It is predicted that the AE-E will reenter the Earth's atmosphere in mid-1981. The Interplanetary Monitoring Platform (IMP)-J continues to provide data on solar wind, cosmic rays, and on the Earth's geomagnetic tail from locations needed to correlate with spacecraft in other locations. The Orbiting Astronomical Observatory (OAO-3), Copernicus, which was launched in 1972, provided a three-axis stabilized automated facility for observing celestial objects and interstellar material in the x-ray and ultraviolet spectral ranges. However, the far ultraviolet detectors aboard OAO-3 have suffered a rapid degradation due to increased levels of solar activity. Since this degradation limits the science that OAO-3 can perform, the mission will be terminated in early 1981. This decision has allowed sufficient time for an orderly completion of the highest priority science observations. Support will be continued to complete analysis of the acquired data.

BASIS OF FY 1982 ESTIMATE:

FY 1982 funds will provide support for the continued operation of the HMO-3 mission and related data analysis activities; the operations and data analysis activities for the Dynamics Explorers-A and -B missions and the Solar Mesosphere Explorer (SME), all scheduled for launch in 1981; data analysis activity for the Cosmic Ray Isotope Experiment (CRIE) which is scheduled for launch on an Air Force spacecraft in 1981; extension of operations and data analysis activity for IUE, ISEE-A, -B, and -C, and IMP-J; and support for continued analysis of the extensive data obtained by HEAO-1, HMO-2, OAO-3, AE-E and the Small Astronomy Satellite (SAS)-C missions. FY 1982 funding will also support the continued operations and data analysis activities of the Solar Maximum Mission (SMM), the continuation of preparations for science operations for the Space Telescope, including the initial development of a Space Telescope Science Institute, and the upgrading of the Science and Applications Computer Center at the Goddard Space Flight Center to insure continued adequate support to ongoing programs.

BASIS OF FY 1981 FUNDING REQUIREMENTS:

RESEARCH AND ANALYSIS

	1980 <u>Actual</u>	<u>1981</u> Budget Current <u>Estimate</u> <u>Estimate</u> (Thousands of Dollars)		1982 Budget <u>Estimate</u>
Supporting research and technology.. .. .	20,974	22,600	22,700	26,700
Advanced technology development	5,800	6,800	8,000	7,700
Data analysis.	<u>7,000</u>	<u>7,300</u>	<u>7,300</u>	<u>8,100</u>
Total.....	<u>33,774</u>	<u>36,700</u>	<u>38,000</u>	<u>42,500</u>

OBJECTIVES AND STATUS:

This program provides for the research and technology base necessary to plan and support flight projects. Preliminary studies to define missions and/or payload requirements are carried out, as are theoretical and ground-based supporting research, and advanced technological development (ATD). Activities included are supporting research and technology (SR&T), ATD, and data analysis.

Supporting Research and Technology (SR&T)

The objectives of supporting research and technology (SR&T) are: (1) to enhance the value of current space missions by carrying out complementary and supplementary ground-based observations and laboratory experiments; (2) to develop theories to explain observed phenomena and predict new ones; (3) to optimize the return expected from future missions by problem definition, development of advanced instrumentation and concepts, and sound definition of proposed new missions; and (4) to strengthen the technological base for sensor and instrumentation development and to conduct basic research necessary to support our understanding of astrophysics and solar terrestrial relationships.

Research is supported in several disciplines of space physics and astronomy. The work in space physics is largely devoted to tasks related to the physics of the Earth's environment and comparative studies of other planetary environments, including the study of Sun-Earth environmental factors. The work in solar and heliospheric physics involves studies of the solar atmosphere and the influence of the Sun on interplanetary and planetary environments. Research supported in astrophysics involves studies of stars, galaxies, interstellar and intergalactic matter and cosmic

rays. The development of new instruments, laboratory and theoretical studies of basic physical processes, and observations by ground-based and balloon-borne instruments are also supported. Results achieved in the SRT program have a direct bearing on future flight programs. For example, the development of advanced x-ray and ultraviolet imaging devices under this program will enable spacecraft in high orbits to watch the flow of energy into the auroral zones.

A major activity in SR&T is the solar terrestrial theory program which provides for theoretical investigations of the predominately plasma physics processes important to solar physics and the solar terrestrial environment. The intent of the program is to enhance and assure the systematic development of scientific investigations of solar system plasmas and for this to play a vital role in the planning of future missions and research efforts.

The SR&T program carries out its objectives through universities, nonprofit and industrial research institutions, NASA centers, and other government agencies. Current emphasis is being placed on studies for advanced instrumentation which will increase both the sensitivity and resolution of detectors. Feasibility and scientific definition studies are being conducted on several potential candidate future explorer missions, including the Cosmic Background Explorer (COBE), the Extreme Ultraviolet Explorer (EUVE), the X-ray Timing Explorer (XTE), the Solar Coronal Explorer (SCE), and the Gravity Probe-B (GP-B). The latter will carry out an experimental test of Einstein's General Theory of Relativity in which measurements would be obtained of the relativistic precession of an extremely stable, cryogenic gyroscope in Earth orbit.

Advanced Technological Development

The advanced technological development (ATD) activities support detailed planning and definition of new Physics and Astronomy missions including Shuttle/Spacelab missions. ATD activities assure that advanced missions address the scientific questions most important to the evolution of knowledge in the field, and that those missions use the appropriate technology and techniques. Funding is applied to the definition and preliminary design for specific missions of subsystems and elements critical to eventual mission development in order that technical readiness and resources may be better defined before the missions are proposed for implementation.

Candidate missions for the 1980's that require ATD activities include the Origin of Plasmas in Earth's Neighborhood (OPEN), the Advanced X-ray Astrophysics Facility (AXAF), the Starprobe, and the Solar Internal Dynamics Mission (SIDM). The OPEN project will study systematically the origin, storage, transport and loss of plasmas in the Earth's environment from input by the solar wind and ionosphere to loss in the atmosphere. The mission will assess the importance to the terrestrial environment of variations in energy input to the Earth's atmosphere caused by geospace processes. The AXAF will study stellar structure and evolution, active galaxies, clusters of galaxies and cosmology. The AXAF 1.2 meter class imaging x-ray telescope is planned to have sensitivity approximately 20 times that of HEAO-2. The Starprobe mission will perform detailed scientific observations of the Sun from a highly elliptical orbit whose aphelion will be within four solar radii of the Sun's surface. The Solar Internal Dynamics Mission (SIDM) will investigate the oscillations visible on the Sun and use the data obtained to study the dynamic state of the Sun's interior.

Major Spacelab payloads requiring advanced technological development support include the following multiuser facilities: the Shuttle Infrared Telescope Facility (SIRTF), a cryogenically cooled telescope which will carry out high sensitivity infrared observations; the Pinhole/Occluder Facility, a coded **mask** and detector for imaging hard X-rays; and the Shuttle Ultraviolet/Optical Telescope (STARLAB), a meter-class UV/optical facility which will be used for high angular resolution imaging investigations of sources that have too great an angular extent to be observed efficiently with the Space Telescope. During FY 1981, major emphasis is being given to definition of the OPEN and AXAF missions. In addition, further definition of Spacelab instruments and facilities will continue, including detailed description of instruments, payload configurations and operational requirements.

Data Analysis

The acquisition, analysis and evaluation of data represents the primary purpose of the laboratory, balloon, rocket and spacecraft activities. While a considerable amount of analysis is done during the prime project phase, experience **has** shown that considerably more time is generally required to reap the full benefit from these programs. The full benefit can be reaped from these programs when the data is correlated with other projects, when detailed cause-and-effect studies are made with data sets from other sources, when very long-term (solar cycle) effects can be studied using complementary sets of data, and when many new ideas can be tested that originate from the results of the initial analysis.

For example, astronomical image processing facilities have been developed to take advantage of high technology developed under the Landsat and planetary programs. This technology allows astronomers to obtain a maximum amount of information from the data they obtain from standard photographic emulsions and more advanced imaging techniques such as the charged-coupled devices (CCD's) now being ground tested for eventual use on the Space Telescope.

Support of the operation of the National Space Science Data Center (NSSDC) is also provided under this program. The NSSDC, located at the Goddard Space Flight Center, **was** established to serve as a central repository and clearing house for scientific data resulting from space investigations. The NSSDC is now in a stage of transition from a repository to a facility where correlative research can be accomplished using data sets from many sources, including active spacecraft. The Satellite Situation Center at NSSDC computes the expected positions of operational spacecraft, so that data acquisition and analysis efforts can be coordinated at times when several spacecraft are favorably situated for correlative geophysical studies.

CHANGES FROM FY 1981 BUDGET ESTIMATE:

The FY 1981 estimate **has** been increased by \$1.3 million as a net result of a specific Congressional appropriation increase for this area partially offset by the general reduction in appropriation requests.

Spacelab science payload definition, previously identified as a separate subitem in this project, is now included in advanced technology development because of the close association of the two activities in the identification and study of future STS payloads.

BASIS OF FY 1982 ESTIMATE

	1980	1981		1982
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of Dollars)		
Supporting research and technology... ..	20,974	22,600	22,700	26,700

During FY 1982, the supporting research and technology program will support those tasks which contribute to maintaining a firm base for a viable physics and astronomy program. Emphasis will be placed on infrared detector development and on expansion of technology activities related to large x-ray mirrors and advanced x-ray detectors and instrumentation. Feasibility and scientific definition studies will be conducted on several potential candidate explorer missions for future years, including Gravity Probe-B, the X-Ray Timing Explorer (XTE) and the Solar Coronae Explorer (SCE). Emphasis will also be placed on the development of a large area electrographic camera for astronomical use, and on the continued development of large array multichannel plate and intensified charge coupled imagery devices. An attempt will also be made to strengthen basic theory support in the program.

In the area of solar physics, activities will support the Solar Maximum Mission through both ground-based observations and theoretical studies of high energy phenomena. New thrusts will be initiated in the development of advanced generation instrument concepts, especially for the extreme ultraviolet and x-ray wavelengths, and for analyzing the internal structure of dynamics of the solar interior. New thrusts will also be established in the area of atmospheric electrodynamics. In the area of theoretical studies, investigations will be carried out by concentrated groups of theorists in the fields of solar, interplanetary, magnetospheric, ionospheric and atmospheric physics in a coordinated program aimed at the understanding of the detailed behavior of each of these components of the solar terrestrial relationship and their interrelationships.

BASIS OF FY 1982 ESTIMATE:

	1980 <u>Actual</u>	1981 <u>Budget</u> <u>Estimate</u> (Thousands of Dollars)	1981 <u>Current</u> <u>Estimate</u>	1982 <u>Budget</u> <u>Estimate</u>
Advanced technological development (ATD)	5,800	6,800	8,000	7,700

The FY 1982 funding will provide for continuation of studies and definition of future missions planned for the 1980's. The FY 1982 funding will allow for further system definition studies, and instrument definition for investigations selected in FY 1980 for the OPEN mission. In addition, funding will support studies on the Advanced X-ray Astrophysics Facility (AXAF), the Starprobe and the Solar Internal Dynamics Mission (SIDM). Definition studies will be continued to assure the technological and scientific readiness of candidate future missions.

FY 1982 funding is also required to support definition of new Spacelab payloads as well as those currently under study.

BASIS OF FY 1982 ESTIMATE:

Data analysis.....	7,000	7,300	7,300	8,100
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Emphasis in the data analysis project, to be carried out at universities and government research centers, will be placed on correlative studies involving data acquired from several sources (spacecraft, balloons, sounding rockets, research aircraft, and ground observatories). FY 1982 funds will also support the operation of the National Space Science Data Center at the Goddard Space Flight Center.

BASIS OF FY 1982 FUNDING REQUIREMENTS

SUBORBITAL PROGRAMS

	1980	1981		1982
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of Dollars)		
Sounding rockets.....	21,700	25,000	25,000	27,700
Airborne research.....	4,326	4,500	4,500	7,300
Balloon program.....	<u>1,200</u>	<u>1,400</u>	<u>1,400</u>	<u>2,500</u>
Total.....	<u>27,226</u>	<u>30,900</u>	<u>30,900</u>	<u>37,500</u>
Sounding rockets.....	21,700	25,000	25,000	27,700

OBJECTIVES AND STATUS:

The sounding rocket program provides versatile, relatively low cost research tools that complement the capabilities of balloons, aircraft, free-flying spacecraft and the Space Shuttle in all the space science disciplines, including the study of the Earth's ionosphere and magnetosphere, space plasma physics, stellar astronomy, solar astronomy, and high energy astrophysics. Activities are conducted on both a domestic and an international cooperative basis. The current level of activity is about 60 rocket flights per year.

A primary objective of the sounding rocket program is to conduct a coordinated research program with flight requirements that cannot be met by vehicles with different performance characteristics. Sounding rockets are uniquely suited for performing low altitude measurements (between balloon and spacecraft altitude) and for measuring vertical variations of many atmospheric parameters. Specific areas of study include the nature, characteristics, and composition of the magnetosphere and near space; the effects of incoming energetic particles and solar radiation on the magnetosphere, including the production of aurorae and the coupling of energy into the atmosphere; and the nature, characteristics, and spectra of radiation of the Sun, stars, and other celestial objects.

Additionally, the sounding rocket program provides the physics and astronomy program with the means for flight testing instruments and experiments being developed for later flight on the Shuttle/Spacelab and space probes; and for calibrating and obtaining vertical profiles in concert with current orbiting spacecraft.

In 1980, fifty rockets were launched from eight locations in the United States, Canada, Sweden, Norway, Kenya, and Antarctica. Those rockets supported the research activities of about fifty groups from universities, private industry, NASA field centers, other government agencies and foreign space organizations.

During N 1980, sounding rocket flights made in correlation with several balloon flights have discovered unexpected electric fields at heights near sixty kilometers. This discovery requires revision of present theories regarding thunderstorm electrical systems and how the atmosphere is coupled to the ionosphere and magnetosphere. An expedition was made to East Africa to support plasma physics and solar physics studies during the solar eclipse in February 1980. Chemical release experiments will continue to be launched on sounding rockets in FY 1981 to measure winds, wind shears, temperatures, plasma motions, and electric fields in support of solar terrestrial studies.

In the astronomy and high energy astrophysics disciplines, continuing emphasis is being placed on development of instruments for studies of stars and extended sources in the ultraviolet (UV) and x-ray spectral regions. Of special interest during 1980 was a flight of an ultraviolet imaging telescope. The instrument obtained high quality photographs of the Andromeda galaxy in both the far and mid-ultraviolet spectra. These data help delineate hot young objects in such galaxies, and will provide important new targets for the Space Telescope. In 1980, the sounding rocket program launched its first Aries rocket with a scientific payload capacity exceeding one ton. The Aries carried a grazing-incidence x-ray telescope which successfully imaged the Cas A supernova remnant and the x-ray source Cyg X-3. Subsequent flights will concentrate on developing x-ray spectroscopic techniques for advanced missions such as AXAF. During 1981, the first flight of a far-ultraviolet spectrograph is planned. This flight will provide a test of the multi-anode microchannel array detector which is a strong candidate for several future ultraviolet and x-ray missions.

BASIS OF FY 1982 ESTIMATE:

FY 1982 funds will provide for continuation of most of the efforts described above. Emphasis will be given to initiation of a concept called Experiments of Opportunity Payloads (EOP) which will make the capabilities of the Shuttle available to sounding rocket experimenters and potentially increase scientific data acquisition periods from the present five minutes per flight up to 24 hours. The EOP concept calls for sounding rocket payloads, technology, and hardware to be launched by the Shuttle into a nearby orbit, operate in a free-flyer mode for up to 24 hours and then be retrieved and returned by the Shuttle. Payloads will be flown on a space available basis and have minimum interface with the Shuttle.

	1980	1981		1982
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of Dollars)		
Airborne research.	4,326	4,500	4,500	7,300

OBJECTIVES AND STATUS:

Research with instrumented jet aircraft has been an integral part of the overall NASA program in physics and astronomy since 1965. The aircraft platform provides a large payload capacity and facilities for extending observations over any region of the Earth. It also may be transported readily to high operational altitude near 15 km (50,000 feet) in order to provide a cloud-free site for auroral geophysics experiments and astronomical observations. The possibility of conducting observations at this cloud-free altitude has been essential in opening to astronomy the infrared region of the electromagnetic spectrum from one micrometer to one millimeter. The airborne platform also **has** the advantage of enabling scientists to participate directly in space research.

The airborne research program utilizes two aircraft, a C-141 instrumented with the 91-cm infrared (IR) telescope and a Lear Jet instrumented for unique individual missions. The C-141A "Kuiper Airborne Observatory", which began operational flights in 1974, is a full-scale, manned facility. The 91-cm f/13.5 infrared telescope operates through an open port, with a pressure bulkhead giving the astronomers a comfortable, shirt-sleeve environment in which to work. The telescope floats on a large air bearing that permits hours of accurate stabilization within a few arc seconds. The weight of this observatory is about 16 tons (14.5 metric tons).

During FY 1980, support **was** provided for two airborne expeditions to Panama and Japan for a planetary occultation and a solar eclipse not observable from the Continental United States. The main thrust of the FY 1981 program will be continued exploration of star forming regions as well as the development of more sensitive instrumentation for both photometry and spectroscopy.

BASIS OF FY 1982 ESTIMATE:

In FY 1982, airborne research funds will be used to continue operations of the Airborne Observatory and the Lear Jet, to provide support for astronomical groups, and to continue the development of improved instrumentation for conducting infrared astronomy.

	1980	1981		1982
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of Dollars)		
Balloon program.... ..	1,200	1,400	1,400	2,500

OBJECTIVES AND STATUS:

For the development of scientific experiments for space flight and for independent scientific missions, it is necessary to test the instrumentation in the space radiation environment and to make observations at altitudes which are above most of the obscuring effects of the atmosphere, particularly for observations in infrared and cosmic ray astronomy. In many instances, it is less expensive to fly these experiments on balloons. The funding for this program is utilized for balloons, helium, launch services, tracking and recovery, while funding for the experiments is provided from the supporting research and technology program.

During 1980, 21 balloons were flown from five global sites to support the research activities of approximately 19 organizations. One of these flights, carrying a 5,000-pound package of ultrasensitive instruments, detected a stream of antimatter from interstellar space--the first such matter ever found outside a terrestrial laboratory. In the infrared astronomy area, about 40 percent of the galactic plane was surveyed resulting in the discovery of many new infrared sources. A solar physics flight succeeded in making the first observation of the spectrum of a solar flare using a high resolution, liquid helium-cooled germanium gamma ray spectrometer.

The FY 1981 funding provides support for about 20 flights including an expedition to Hawaii for carrying out scientific research in High Energy Astrophysics. In infrared astronomy, the survey of the galactic plane will be continued, which will provide additional information on the rate of star formation in our Milky Way system.

BASIS OF FY 1982 ESTIMATE:

The FY 1982 funding provides for continuation of the balloon program with approximately the same number of flights as in FY 1981. In infrared astronomy, emphasis will be on continuing the survey of the galactic plane and using new techniques to better understand how stars are formed, prior to designing instruments for Spacelab.

PLANETARY
EXPLORATION



RESEARCH AND DEVELOPMENT

FISCAL YEAR 1982 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE

PLANETARY EXPLORATION PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1980 <u>Actual</u>	1981 <u>Budget</u> <u>Estimate</u> (Thousands of Dollars)	1981 <u>Current</u> <u>Estimate</u> (Thousands of Dollars)	1982 <u>Budget</u> <u>Estimate</u>	Page <u>No.</u>
GALILEO development.....	116,100	63,100	63,100	108,000	RD 5-5
Venus orbiting imaging radar (VOIR) development.. ..	---	---	---	40,000	RD 5-6
Mission operations and data analysis.. ..	58,800	60,500	61,800	50,900	RD 5-8
Research and analysis.. ..	<u>45,000</u>	<u>51,700</u>	<u>50,700</u>	<u>57,200</u>	RD 5-11
Total.....	<u>219,900</u>	<u>175,300</u>	<u>175,600</u>	<u>256,100</u>	
<u>DISTRIBUTION OF PROGRAM AMOUNT BY INSTALLATION:</u>					
Johnson Space Center.....	7,495	5,990	8,259	8,984	
Marshall Space Flight Center.	122	75	135	200	
Goddard Space Flight Center.	4,290	3,680	3,756	4,546	
Jet Propulsion laboratory.. ..	139,321	101,877	104,276	173,402	
Ames Research Center.....	40,049	24,140	26,894	30,279	
Langley Research Center.....	7	---	---	---	
Headquarters.....	<u>28,616</u>	<u>39,538</u>	<u>32,280</u>	<u>38,689</u>	
Total.....	<u>219,900</u>	<u>175,300</u>	<u>175,600</u>	<u>256,100</u>	

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1982 ESTIMATES

OFFICE OF SPACE SCIENCE

PLANETARY EXPLORATION PROGRAM

LAUNCH SCHEDULE

PROJECT

MISSION

**CALENDAR
YEAR**

GALILEO

GALILEO

1985

Venus Orbiting Imaging Radar (VOIR)

VOIR

1986

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1982 ESTIMATES

OFFICE OF SPACE SCIENCE

RATION PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The planetary program includes the scientific exploration of the planets and their satellites, comets and asteroids, and the interplanetary medium. The program objectives are to understand the origin and evolution of the solar system, to better understand the Earth through comparative studies with the other planets, and to understand how the appearance of life in the solar system is related to the chemical history of the system. The projects undertaken in the past have been highly successful. The strategy that **has** been adopted calls **for** a balanced emphasis on the terrestrial-like inner planets, the giant gaseous outer planets, and the **small** bodies (comets and asteroids). Missions to these planetary bodies start at the level of reconnaissance and exploration **to** achieve the most fundamental characterization of the bodies, and proceed to a level of detailed study. The reconnaissance phase of inner planet exploration began in the 1960's, and **has** now been completed. **Mars** has provided program focus because of its potential **as** a site of biological activity. The Viking landings in 1976 carried the exploration of this planet forward to a new level of scientific and technological achievement, thereby setting the stage for the next step of detailed study. Analyses of the moon rock samples returned by Apollo continue to be highly productive as new insights into the early history of the inner solar system are achieved and as our theoretical concepts are revised accordingly. The continuing Pioneer Venus mission is carrying the study of our nearest neighbor, and closest planetary analogue, beyond the reconnaissance stage to the point where we have made a basic characterization of the massive cloud-covered atmosphere of Venus. This characterization **has** also provided some fundamental data about the formation of the planet. However, because of the opacity of the atmosphere, information about the Venus surface character remains sparse. Therefore, the highest priority goal of the planetary program is to fill in this missing data. Accordingly, the Venus Orbiting Imaging Radar mission to map the entire surface of Venus at about one kilometer resolution will be initiated in FY 1982 leading to a 1986 launch by the Space Shuttle.

The exploration of the giant outer planets began relatively recently with the Pioneer 10 and 11 flybys of Jupiter in 1973 and 1974. These simple reconnaissance spacecraft have returned excellent data which contributed significantly to the success of the flybys of two Voyager spacecraft through the Jovian system in the spring and summer of 1979. In **Nwember** 1980 the Voyager 1 spacecraft made a historic encounter with Saturn, passing close to its ring system and to Titan, as well as **providing** a first closeup view of several of the other moons. The Voyager 2 spacecraft is still enroute to Saturn where encounter will take place in August 1981. The first closeup examination of Saturn occurred in September 1979 when Pioneer 11 reached that planet after receiving a gravity-assist at Jupiter five years earlier. Numerous discoveries were made as a result of this encounter and it **was** demonstrated that a safe, close passage by

Saturn's rings could be made. Voyager 2 will encounter Saturn in 1981 and then proceed on to Uranus for a 1986 flyby. Pioneer 10 is well beyond the orbit of Uranus and is on its way out of the solar system. It is continuing to provide new information about a previously uncharted region of interplanetary space.

The Galileo mission is a cooperative effort between the United States and the Federal Republic of Germany. A wide range of science experiments, chosen to make maximum progress beyond the Voyager findings, has been selected. The Galileo development efforts are proceeding on a schedule which will permit an early 1985 launch.

The pre-eminence of the United States program of planetary exploration has been based on technology leadership and on a foundation of strong, coordinated research and analysis programs. These programs ensure that full advantage is taken of the spacecraft data and samples acquired on completed and ongoing missions, and that the necessary research is performed to maximize the return from ongoing and future missions. Included in the research and analysis efforts are data analysis, lunar sample and meteorite analysis, telescopic observations, theoretical and laboratory studies, and instrument definition. The highest scientific standards are maintained in these programs and both new and old concepts are subject to intense scrutiny. The programs also involve interdisciplinary coordination among various research groups. The results of the research is widely disseminated. The lunar sample analysis effort is mission-oriented and is coordinated with research by the National Science Foundation. A close coupling is maintained between the research programs and the planning activities that are undertaken to define the scientific rationale and technology needs for future missions.

Comets and asteroids have, to date, not been investigated by spacecraft missions. Comet rendezvous and flyby mission definition studies are being conducted as technology advances bring exploration of these small bodies within our grasp. Study of these primitive objects hold the promise of a breakthrough in our understanding of the nature of the early solar system.

BASIS OF FY 1982 FUNDING REQUIREMENTS:

GALILEO DEVELOPMENT

	1980	1981		1982
	<u>Actual</u>	<u>Budget</u> <u>Estimate</u> (Thousands of Dollars)	<u>Current</u> <u>Estimate</u>	<u>Budget</u> <u>Estimate</u>
Spacecraft.....	89,222	42,184	46,541	79,836
Experiments.....	19,390	11,900	10,435	12,181
Ground operations.....	<u>7,488</u>	<u>9,016</u>	<u>6,124</u>	<u>15,983</u>
Total.....	<u>116,100</u>	<u>63,100</u>	<u>63,100</u>	<u>108,000</u>
Space transportation system operations.....	(8,300)	(10,400)	(15,400)	(41,800)

OBJECTIVES AND STATUS:

The Galileo mission, which will conduct direct and long-duration studies of Jupiter, is a vital link in providing the continuity, balance and orderly progression of the exploration of the solar system.

The objective of this program is to conduct a comprehensive exploration of Jupiter, its atmosphere, magnetosphere and satellites, through a new deep space spacecraft concept which combines both remote sensing and direct measurements by an orbiter and an atmospheric probe.

The Galileo mission will utilize a single Space Shuttle launch in 1985 for the Galileo orbiter and probe. The orbiter and probe will arrive on target in mid 1987 to conduct a twenty-month investigation of Jupiter, its satellites, and its magnetosphere. Eleven encounters with the satellites of Jupiter are planned during the tour. The probe will penetrate the atmosphere of Jupiter to conduct scientific investigations down to a depth where the pressure is equivalent to ten times the pressure exerted by the Earth's atmosphere, and the orbiter will relay information gathered back to Earth.

The Galileo launch has recently been slipped from a 1984 launch to a 1985 launch due to IUS development difficulties which resulted in marginal capability to launch the Galileo spacecraft in 1984. The effect on the cost estimate through completion has not yet been determined.

In FY 1981, the orbiter and probe design, development and fabrication activities will continue and the critical design reviews for most of the major subsystems will be completed.

CHANGE FROM FY 1981 BUDGET ESTIMATE:

The FY 1981 Galileo estimate remains unchanged in total; however, adjustments have been made within the project. The spacecraft funding was increased to allow for the purchase of a lighter and more efficient radioactive energy source. To offset this increase, some experiment and ground operations activities were shifted downstream.

BASIS OF FY 1982 ESTIMATE:

The FY 1982 funding will provide for continuation of the orbiter, probe, and scientific instruments design. Preliminary parts deliveries, breadboard development and subsystem fabrication and testing will be continued for both the orbiter and probe spacecraft.

BASIS OF FY 1982 FUNDING REQUIREMENTS:

VENUS ORBITING IMAGING RADAR (VOIR) DEVELOPMENT

	1980 <u>Actual</u>	<u>1981</u> Budget Estimate Current Estimate (Thousands of Dollars)		1982 <u>Budget Estimate</u>
Spacecraft.....	---	---	---	17,600
Experiments.....	---	---	---	19,500
Ground operations.....	---	---	---	2,900
Total.....	---	---	---	<u>40,000</u>
Space transportation system operations.....	(---)	(---)	(---)	(6,600)

OBJECTIVES AND STATUS:

The Venus Orbiting Imaging Radar (VOIR) mission will map Venus by means of a Synthetic Aperture Radar (SAR) instrument on an orbiting spacecraft. The VOIR mission will produce radar images, of Venus' surface which will be comparable in resolution and quality to the optical images obtained previously for the other planets of the inner solar system. This mission is the next logical step in the exploration of the solar system to advance our comparative planetology studies.

The major objective of the VOIR program is to use radar imagery to investigate the surface morphology of Venus on a global scale. The radar imagery will pierce the thick atmosphere and continuous cloud cover of Venus to give us our first detailed view of the surface topography and reveal the presence or absence of plate tectonic activity, impact craters, volcanoes, mountains, and erosional processes. Secondary objectives are to use altimetry and gravity data to investigate the global shape, crustal thickness, and interior of the planet.

Venus is the nearest planet to Earth, and is believed to be most like the Earth in many physical aspects, although Venus remains an enigma because of its complete cloud shroud. In the study of comparative planetology, it is important to understand how and when Venus and the Earth diverged in their evolutionary paths, and try to answer the following questions: Why does Venus have such a dense atmosphere, lacking water and oxygen? Has plate tectonics played an important role in shaping the Venusian topography? Has volcanism been a major contributor to the atmosphere and surface characteristics as it has on Earth? Does the surface still retain a record of early impact cratering, now largely erased on Earth?

The VOIR spacecraft will be launched by the space transportation system in mid-1986. After an inactive cruise period, the spacecraft will reach Venus in late 1986 where it will perform a propulsive maneuver for orbit insertion. The initial polar elliptical orbit will be modified to yield a circular orbit at approximately 250 km above the surface. When this desired orbit has been achieved, the spacecraft will be commanded to deploy its solar panels, communication antenna, and large radar antenna into the mapping configuration. The spacecraft will be operated in a nadir-pointing, 3-axis-stabilized attitude so the altimeter is always pointing directly below, and the side-looking radar antenna is sweeping a 30 km swath over the surface of Venus. The complete mapping of the planet will take about four months with over 90% of the surface imaged with a resolution of 600 meters. Systematic coverage of a much smaller area will be provided at a higher resolution of 150 meters. The radar imaging data will be transmitted to Earth over an X-band radio link at a rate of one megabit per second. The raw radar data will be processed by digital computing equipment at the Jet Propulsion Laboratory to produce image strips.

Concurrently with the radar imaging operations, the spacecraft will operate the synthetic aperture radar in an altimeter mode to measure the absolute elevations of the imaged terrain. Doppler shifts in the radio signals from the spacecraft will be analyzed to investigate the gravity field of Venus which should tell us a great deal about the interior of Venus.

The current planning estimate for the VOIR is \$500-560 million. This includes development through launch plus thirty days in-flight checkout. The estimate for support during the approximately one-year mission operations period and for analysis of the scientific data is \$45-75 million. The estimate for Space Transportation System support is approximately \$100 million.

BASIS OF FY 1982 ESTIMATE:

The FY 1982 funding is required to initiate the design of both the VOIR spacecraft and the synthetic aperture radar, as well as for the initiation of the development of the nonimaging science instruments.

BASIS OF FY 1982 FUNDING REQUIREMENTS:

MISSION OPERATIONS AND DATA ANALYSIS

	1980	1981		1982
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of Dollars)		
Voyager basic mission.....	19,000	25,600	25,600	
Voyager extended mission.....	---	3,000	3,300	18,000
Pioneer Venus basic and extended mission.....	8,251	5,000	4,700	6,300
Pioneer 6-11 extended mission.....	2,800	1,000	2,000	2,000
Helios extended mission.....	100	---	142	---
Viking extended mission.....	2,450	---	---	---
Planetary flight support.....	<u>26,199</u>	<u>25,900</u>	<u>26,058</u>	<u>24,600</u>
Total.....	<u>58,800</u>	<u>60,500</u>	<u>61,800</u>	<u>50,900</u>

OBJECTIVES AND STATUS:

The mission operations and data analysis program funds the operation phase of planetary missions after development, launch, and initial in-flight checkout are complete. It also provides for multimission flight support. Currently, active planetary missions being supported within mission operations and data analysis are Voyagers 1 and 2, Pioneer Venus, Pioneer 6-11, Helios 1 and 2, and Viking Lander 1.

The objective of the Voyager mission was to conduct comparative studies of the Jupiter and Saturn planetary systems and to perform studies of the interplanetary medium between the Earth and Saturn. Since their launches in 1977, the two Voyager spacecraft have encountered Jupiter and investigated its system. Voyager 1 has since encountered Saturn and investigated its numerous satellites and rings. Voyager 1 is now on a cruise trajectory which will take it out of the solar system at a steep angle to the plane of the ecliptic. The spacecraft is continuing to collect data on the space environment as it proceeds to investigate the outer limits of our solar system. Voyager 2 is currently on a cruise trajectory to Saturn. Saturn encounter operations for Voyager 2 will begin in June 1981, and the closest approach to Saturn will occur in August 1981. Subsequent to this encounter, the spacecraft will continue to provide data on the interplanetary medium as it continues on to Uranus. Both spacecraft appear to be in good condition although the primary Canopus Star Tracker on Voyager 1 has experienced degraded performance. The backup system, however, appears to be operational. The primary radio receiver on Voyager 2 has failed but the spacecraft can continue to be operated successfully by using its backup receiver, even though that equipment is somewhat impaired by a component failure.

The objective of the Pioneer Venus mission was to obtain detailed information on the Venusian atmosphere, to investigate the planet's environment and to learn why the planet, so Earth-like in many respects, has an atmosphere so different. The mission consisted of two spacecraft: an orbiter launched in May 1978 and a multiprobe launched in August 1978. The orbiter arrived at Venus on December 4, 1978, and the four probes and multiprobe bus entered the atmosphere on December 9, 1978. The mission has been, and continues to be, an outstanding success.

The objective of Pioneers 6-9 was to explore interplanetary space at radial distances from the Sun varying from 0.75 to 1.1 AU (The Earth's distance from the Sun is 1 AU, an astronomical unit). The objective of Pioneer 10 and 11 was to explore space beyond 1 AU, the Asteroid Belt, and the environment of Jupiter. Pioneers 6-9, which were launched in 1965, are still operational. However, data is acquired only when unusual solar activities or special alignment with other spacecraft occur. Pioneer 10, launched in 1972, reached Jupiter in December 1973, and the gravity of the massive planet provided the extra impetus to ultimately take the spacecraft out of the solar system. Pioneer 11, launched in 1973, passed Jupiter in December 1974, and the spacecraft trajectory was influenced by the planet's gravity field in such a way so that it flew by Saturn in 1979. Both spacecraft have returned excellent data and continue to operate successfully.

During FY 1981, the Viking spacecraft is continuing to collect data at a reduced level. The Lander-1, which is capable of transmitting directly to Earth on command, is the only Viking spacecraft still in operation. This lander is in an automatic mission mode, in which it collects and stores selected data at reduced levels for transmission to Earth at periodic intervals.

Planetary flight support provides for mission control and other activities which support the tracking, telemetry, and command functions for all planetary spacecraft. These activities include the acquisition, operation, and maintenance of mission operations and general purpose scientific and engineering computing capabilities at the Jet Propulsion

Laboratory (JPL), and selected project functions such as preparation of data records. These functions are performed at the mission control and computing center at JPL.

CHANGES FROM FY 1981 BUDGET ESTIMATE:

The \$1.3 million increase in the current FY 1981 budget is a result of a specific Congressional increase for mission operations and data analysis in the amount of \$4.3 million, offset by the application to this project of a portion of the general Congressional reduction to overall appropriation requests. Of the \$1.3 million increase, \$300,000 will be used for Jupiter data analysis activities in light of the large volume of interesting data returned from the Voyager Jupiter encounters. \$1.0 million of the Pioneer 6-11 data analysis budget amendment reductions were restored and planetary flight support reflects a minor increase of \$158,000. Helios operations will also be continued into FY 1981, as reflected by the increase of \$142,000 to take advantage of the excellent opportunity to collect data during a period of high solar activity in which large events are often occurring at the rate of several per week. A \$300,000 decrease in the Pioneer Venus extended mission has been achieved without impact on science data acquisition.

BASIS OF FY 1982 ESTIMATE:

The successful encounters at Jupiter by Voyager 1 and 2 and at Saturn by Voyager 1 have resulted in numerous scientific discoveries, high demand for the image products, and a large data base for intense analysis by the scientific community. The FY 1982 funding will provide for continuation of Voyager 1 post-Saturn encounter mission operations and for the initial phase of the Voyager 2 cruise to Uranus. Analysis and publication of the results of the Jupiter and Saturn encounters will be continued in FY 1982. In addition, funds are also required for analysis of the data obtained during the Pioneer Venus mission and for continuation of Pioneer 6-11 mission operations and data analysis.

FY 1982 planetary flight support funds will provide mission control and computing support for all active deep space missions.

BASIS OF FY 1982 FUNDING REQUIREMENTS:

RESEARCH AND ANALYSIS

	1980 <u>Actual</u>	1981		1982
		<u>Budget Estimate</u>	<u>Current Estimate</u>	<u>Budget Estimate</u>
		(Thousands of Dollars)		
Supporting research and technology	33,600	37,500	37,500	41,300
Advanced programs.....	5,400	7,800	7,800	8,500
Mars data analysis.....	6,000	6,400	5,400	3,700
Halley's comet co-investigations and watch.....	---	---	---	2,000
Infrared telescope mid-level facility.....	---	---	---	1,700
Total.....	<u>45,000</u>	<u>51,700</u>	<u>50,700</u>	<u>57,200</u>

OBJECTIVES AND STATUS:

The research and analysis program contains five elements required to assure that data and samples returned from flight missions are fully exploited; to undertake complementary laboratory and theoretical efforts; to define the science rationale and develop required technology to undertake future planetary missions; to coordinate an International Halley's Comet Watch and provide co-investigative support to the European Space Agency's Giotto mission to Halley's comet; and to purchase a share of a facility to provide accommodations for visiting scientists to the Infrared Telescope facilities on Mauna Kea, Hawaii. This facility will be titled to the University of Hawaii.

Supporting Research and Technology -- The supporting research and technology is made up of six areas of effort: (1) planetary astronomy; (2) planetary atmospheres; (3) planetary geochemistry and geophysics; (4) planetary geology; (5) planetary materials; and (6) instrument definition.

The planetary astronomy activity includes all planetary observations made by ground-based, airborne and Earth-orbital telescopes. Observations are made at a wide range of wavelengths from ultraviolet to radio. The rate of new discoveries continues to be high. The data acquired are used both for basic research in support of planetary program objectives and for direct support of specific flight missions.

In the spring of 1979, the new Infrared Telescope Facility in Hawaii commenced planetary observations, and in October 1979 became fully operational. In addition to planetary observations, the Facility has provided support to the

Voyager 2 encounter of Jupiter and the Voyager 1 encounter of Saturn. Investigations of the infrared properties of the outer planets and their moons are underway and have already produced valuable results.

The planetary atmospheres activity includes data analysis, and laboratory and theory efforts. The properties of other planetary atmospheres are amenable to measurement and can aid us in better understanding our **own** weather and climate. Observations of the atmospheres of Venus and of Jupiter, acquired by Pioneer Venus and by Voyager, will lay the basic groundwork for major advances in knowledge in atmospheric sciences.

The planetary geochemistry and geophysics activity is broad in scope and includes studies of the composition and structure of all classes of solar system objects and the synthesis of data from all sources that relate to the origin and evolution of the solar system. The program supports the synthesis of planetary data already obtained, and the assembly of information needed to prepare for future missions. Both Voyager and Pioneer Venus are providing key data for the research efforts undertaken in this program.

To date, the planetary geology activity has focused on studies of the inner planets (including the Moon). Voyager data pertaining to the moons of Jupiter and Saturn have provided a new dimension for this effort. The geology program is **a** broadly based effort in which comparative studies of **common** processes affecting all the inner planets provide a powerful technique for unravelling individual planetary histories, including their early states. Imaging data, both from spacecraft and from ground-based radar, provide the basis for much of the data analysis.

The planetary materials activity supports an active scientific effort to determine directly the chemistry, mineral composition, age, physical properties, and other characteristics of returned lunar samples and of meteorites that fall to Earth. Recently, extraterrestrial dust grains have been collected for analysis. These studies continue to yield new and otherwise unobtainable information about the solar system, particularly about its early history. NASA maintains a balanced program of work on extraterrestrial materials consistent with its mission. This program **is** coordinated with lunar sample research supported by the National Science Foundation.

The instrument definition activity is directed toward ensuring that the science return from future spacecraft missions **is** maximized by the availability of state-of-the-art scientific instrumentation. Most of the effort is currently directed toward the definition of instrumentation for an eventual rendezvous mission to a comet.

Advanced Programs -- The objective of advanced programs **is** to provide planning and preparation for the systematic exploration of the solar system on a scientifically and technically sound basis. Prospective planetary missions are identified and defined through long-range studies; their technological and fiscal feasibility is evaluated, and their scientific merit is assessed through interaction with the scientific community. For near-term missions, detailed project planning and technology readiness studies are carried out **so** that these missions may be undertaken on schedule and within fiscal constraints.

Mars Data Analysis -- The Mars Data Analysis activity continues to assure that we fully capitalize on the wealth of data provided by Viking. The activity covers the broad scope of the returned data related to the disciplines of biology, chemistry, geology, and meteorology.

Halley's Comet Co-Investigations and Watch -- The International Halley's Comet Co-Investigations and Watch will capitalize on the opportunity to observe Comet Halley during its next apparition in 1985-86 by supporting co-investigating scientists on the European Space Agency (ESA) Giotto mission and by conducting complementary remote sensing investigations using both Earth orbiting and ground-based facilities. ESA is planning its Giotto mission to fly by Halley in March 1986, and NASA has been invited to participate with co-investigators supporting various experiments on the mission. Concurrently, an observation program called the International Halley Watch will be conducted to coordinate scientific observations of Comet Halley, and the United States will act as a liaison between observations, Earth orbital missions, and deep space missions.

Thus far, all knowledge about comets and their place in the solar system has come from Earth-based operations. Although these observations are extremely valuable and should be continued, it will ultimately be necessary to plan and execute a reconnaissance mission to one of these bodies before parity in knowledge with the planets can be achieved. The return of Comet Halley in 1985-86 from its 76-year long trek around the Sun will offer a rare opportunity to continue the remote sensing observing program and, at the same time, to participate in a space mission being flown by another nation, thus providing a major step toward closing that knowledge deficit. It is the intent of the Halley's Comet co-investigations and watch to take advantage of this opportunity to significantly further our knowledge of comets.

NASA participation on the ESA Giotto mission will include reviewing on a case-by-case basis each experiment which is selected by ESA and which has a United States co-investigator, and if the selected experiment shows scientific return, then resources will be provided to cover the activity of the respective United States investigator.

The second aspect of the Halley Comet Co-Investigations and Watch is the International Halley Watch Program. The objectives of the Watch are: (1) to coordinate scientific observations of Comet Halley throughout its 1985-1986 apparition; (2) to promote the use of standardized instrumentation and observing techniques; (3) to help insure that data are properly documented and archived; and (4) to receive and distribute data to participating scientists.

CHANGES FROM FY 1981 ESTIMATE:

The decrease of \$1.0 million in research and analysis is due to the Congressional general reduction in overall appropriation requests.

BASIS OF FY 1982 ESTIMATE:

	<u>1980</u> <u>Actual</u>	<u>1981</u> Budget <u>Estimate</u> (Thousands of Dollars)	Current <u>Estimate</u>	1982 Budget <u>Estimate</u>
Supporting research and technology... ..	33,600	37,500	37,500	41,300

During FY 1982, research efforts will continue in the areas of planetary astronomy, planetary atmospheres, planetary geochemistry and geophysics, planetary geology, planetary materials, and instrument definition. Infrared telescopic observations of Saturn will be undertaken in support of the Voyager missions, and radar telescopes will be used to continue the investigation of Venus and other solar system bodies. Other significant observations will be conducted both to increase our knowledge of the outer planets and the small bodies of the solar system, and to advance our readiness for future missions. A variety of efforts will be pursued to improve our understanding of planetary atmospheres, including laboratory studies of reactions in deep atmospheres and in tenuous cometary atmospheres. In the geochemistry-geophysics area, research efforts will be made to better understand the present state and evolution of individual bodies and of the solar system in general. Geology research will be directed at specific problems in understanding the various processes that have shaped planetary surfaces, and will also include geological analyses and a cartography effort based on the Galilean satellite imaging data acquired by Voyager. Analysis of lunar samples, meteorites, and cosmic particles will continue in order to determine their chemical and physical properties and thereby to derive their origin and evolutionary history. Instrument definition for future missions will be continued in FY 1982.

Advanced programs.....	5,400	7,800	7,800	8,500
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In FY 1982 work will proceed on advanced mission definition, and on instrument definition and development in support of future cometary and other planetary science mission opportunities.

Mars data analysis.....	6,000	6,400	5,400	3,700
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The Mars data analysis activity which began in FY 1979 has provided support for over 80 research efforts in a wide range of discipline areas such as biology, chemistry, geology, and meteorology. The FY 1982 funds will provide for the completion of these efforts and the initiation of new analyses.

	1980	1981		1981	Page
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>	<u>No</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>	
		(Thousands of Dollars)			
Halley's comet co-investigations and watch.....	---	---	---	2,000	

The FY 1982 Halley's Comet Co-Investigations and Watch funding is required to install a group of scientists at the Jet Propulsion Laboratory who in turn will select discipline groups to organize international groups of astronomers to define data acquisition and archiving requirements.

Infrared telescope mid-level facility.....	---	---	---	1,700
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The Infrared Telescope Mid-Level Facility is required to provide accommodations and services for visiting scientists to the astronomical facilities on Mauna Kea, Hawaii. The United Kingdom, France, Canada, and the State of Hawaii are also providing funding for this facility which will be located at a 9,200 foot elevation on Mauna Kea. This facility will enable the scientists to reside at this level while performing their planetary research with the telescopes at the summit sites which are at approximately 14,000 feet. Accommodations must be provided approximately mid-way up the mountain in order for the scientists to maintain a healthy physical balance between the extremely high elevation of the telescope viewing sites and the foot of the mountain where hotel facilities are available. A memorandum of understanding between the University of Hawaii and NASA will be effected stipulating NASA's proportionate share and occupancy of the accommodations. This facility will be designed and provided by contract by the University of Hawaii on land provided by the State of Hawaii, and the FY 1982 funding is required for NASA's proportionate share. Under Section 1(d) of the FY 1982 Authorization Act, following required notifications, a grant will be awarded to the University of Hawaii to provide funding for the mid-level facility. The University of Hawaii will operate and maintain this permanent facility and shall be vested with title to the facility.

LIFE
SCIENCES

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1982 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE

LIFE SCIENCES PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1980 <u>Actual</u>	1981 <u>Budget Estimate</u> (Thousands of Dollars)	1981 <u>Current Estimate</u> (Thousands of Dollars)	1982 <u>Budget Estimate</u>	Page <u>No.</u>
Life sciences flight experiments.....	16,600	12,700	12,700	16,500	RD 6-4
Research and analysis.....	<u>27,200</u>	<u>26,400</u>	<u>29,488</u>	<u>32,700</u>	RD 6-5
Total.....	<u>43,800</u>	<u>39,100</u>	<u>42,188</u>	<u>49,200</u>	
<u>Distribution of Program Amount by Installation:</u>					
Johnson Space Center.....	16,543	16,650	13,806	15,381	
Kennedy Space Center.....	832	1,029	802	1,534	
Goddard Space Flight Center.	25	---	35	39	
Jet Propulsion Laboratory.....	2,275	1,166	1,123	1,245	
Ames Research Center.....	16,092	12,497	15,371	18,576	
Dryden Flight Research Center.....	108	288	555	615	
Langley Research Center.....	40	40	---	---	
Redstone	<u>7,885</u>	<u>7,430</u>	<u>10,496</u>	<u>11,810</u>	
Total.....	<u>43,800</u>	<u>39,100</u>	<u>42,188</u>	<u>49,200</u>	

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1982 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE

LIFE SCIENCES PROGRAM

The objective of the Life Sciences program is to support NASA's overall goals and objectives in the exploration and utilization of space by conducting studies in space biology, and medicine, by expanding scientific knowledge of the origin and evolution of life, and by developing technology for the support of human life during long-duration space flight. The realization of this objective, which is intimately linked to our understanding of the basic mechanisms of biological processes, is achieved through a program of research conducted both on Earth and in space. The near-term activities will help us to understand the effects of the space environment on humans, facilitating their safety, and maximizing their productivity during space flight. This is accomplished by a pattern of research which cycles from the ground-based research activities to flight experiments, and then from flight experiment results back to laboratory work on Earth. Thus, the life sciences program utilizes a composite of disciplines and techniques to address space-related problems in biology and medicine.

The Life Sciences program is composed of four major program thrusts. The first is the space biology program which consists of flight and ground-based experiments that focus on understanding the effects of the space environment on plants and animals. The unique properties of space (e.g., micro-gravity, radiation, etc.) provide, for the first time in our history, an opportunity to explore significant problems in biology under a controlled set of conditions that cannot be adequately duplicated in laboratories on Earth. The second thrust is a combination of operational medicine and biomedical research. The third program thrust is the study of exobiology, with special emphasis on the origin and the distribution of life in the universe. The fourth thrust is the research and associated technology necessary to maintain life in space autonomously for long periods of time (e.g., advanced life support systems).

The objectives of space biology are met by ground-based research and flight opportunities on the Shuttle as well as flight opportunities provided by the Soviet Union's Biological Satellite program. One flight experiment is being developed to be flown on one of the Shuttle's orbital flight tests (OSS-1) mission and seven experiments are being developed by NASA for the Spacelab-1 mission. These experiments emphasize the study of the effects of space flight on living organisms, such as changes in vestibular function and hematological indices, the impact of space radiation, and the effect of gravity on plant growth and biological rhythms.

The goals of the operational medicine and biomedical research programs are to assure astronaut and payload specialist health and their ability to function effectively in the space environment, which in turn, will allow a broader segment

of the population to participate in all aspects of future space missions. Particular emphasis is placed on the early detection and prevention of debilitating diseases, and on the testing of countermeasures designed to prevent untoward physiological responses associated with exposure to the space environment. It is essential that continuous long-term monitoring of the Space Transportation System crew is performed in a standard and organized fashion in order to establish the long-term clinical significance, and develop of risk factors which might be associated with repeated exposure to the space environment.

The goals of the exobiology area seek to understand the origin and distribution of life throughout the universe. Particular emphasis is placed on developing sound hypotheses which ultimately will lead to discovering the relationships which link the beginnings of life to the formation of the solar system. Ground-based research on model systems and analysis of extraterrestrial materials, coupled with planetary flight experiments, are clarifying the mechanisms of, and environments conducive to, the formation of essential biomolecules. Another ground-based research field is the detection of extraterrestrial radio signals which would be indicative of the presence of intelligent life. This is an outgrowth of planetary biology.

The objective of the advanced life support systems is the fourth major thrust. This work ranges from the development of improved suits for the astronauts; suits that are less constraining and more efficient, to the scientific work in chemistry and biology necessary to understand how life maintains itself in systems which only receive energy from the external environment.

BASIS OF FY 1982 FUNDING REQUIREMENTS:

LIFE SCIENCES FLIGHT EXPERIMENTS

	<u>1980 Actual</u>	<u>1981</u> <u>Budget</u> <u>Estimate</u> (Thousands of Dollars)	<u>Current</u> <u>Estimate</u> (Thousands of Dollars)	<u>1982</u> <u>Budget</u> <u>Estimate</u>
Life sciences flight experiments.....	16,600	12,700	12,700	16,500
Space transportation system operations.	(---)	(12,000)	(---)	(7,000)

OBJECTIVES AND STATUS

The objective of the life sciences flight experiments program is to expand our understanding of the basic mechanisms and time course of biological and medical processes as they occur during exposure to zero gravity. The program includes experiment design, development, inflight execution, data analysis, and reporting.

Management of life sciences flight experiments involves two main areas of development activities. The first area involves the selection and development of science experiments for flight. The second area encompasses the development of as much general purpose flight hardware (laboratory equipment) as is feasible to support the flight experiments, thus avoiding unnecessary duplication of development costs.

Current activities involve the development and fabrication of life sciences flight experiments for early Shuttle/Spacelab flights (e.g., OSTA-1, OSS-1, Spacelab-1, and Spacelab-2). Selection of the life sciences flight hardware which will fly on Spacelab 3 is in the final stages. Definition studies have been completed on the experiments planned for the first dedicated life sciences Spacelab mission (Spacelab 4) and information from the definition studies has been closely coupled with the general purpose laboratory equipment now under development.

Another element of the life sciences flight experiment program is the United States participation on Soviet Cosmos flights which involves the development of experiment hardware and the analysis of flight data. The results from the United States experiments flown on Cosmos 1129, which was launched in October 1979, have recently been published. United States participation on the next Cosmos flight, which is scheduled for 1982, has been negotiated with the Soviets. The Cosmos flights allow a science data opportunity for the United States and, more specifically, an opportunity to prepare for future Shuttle/Spacelab missions.

BASIS OF FY 1982 ESTIMATE:

The FY 1982 funding is required for the continuing definition and development of experiments which will be flown on future Spacelab missions. For example the experiment flown on **OSS-1** will be refurbished to be part of the payload on Spacelab-2, along with the development of an additional life sciences experiment. Development of the life sciences payload for Spacelab-3 will be completed in FY 1982, and assembly and test will be initiated. Payload selection for the first dedicated Life Sciences Spacelab mission will also be completed in FY 1982 and development of flight hardware **will** be initiated and participation in the Swiet Cosmos program will be continued. The FY 1982 funding is **also** required for analysis of data from the United States experiments flown on the Cosmos 1129 mission.

BASIS OF FY 1982 FUNDING REQUIREMENTS:

<u>RESEARCH AND ANALYSIS</u>				
	1980	1981		1982
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of Dollars)		
Life sciences research and analysis.. .. .	27,200	26,400	29,488	32,700

OBJECTIVES AND STATUS:

The research and analysis activities of the life sciences program represent the ground-based research in space related biological and biomedical problem areas that have been identified in previous manned flights. The program is comprised of five elements: (1) operational medicine, (2) biomedical research, (3) space biology, (4) exobiology, and (5) life support systems research.

The life sciences operational medicine program is the catalyst responsible for bringing the science, technology, and practice of medicine to bear on solving the problems of sustaining, supporting, and protecting individuals working in the space environment. This includes assurance that physical welfare and performance is preserved and that adequate treatment of in-flight illnesses or injuries is provided. The space transportation system will allow for a complement of crews of varied background, age, and sex, who will work for different lengths of time in the unique environment of space. Thus, a new dimension of frequent and repetitive exposure to zero-gravity will be introduced. Such manifestations as "space motion sickness", fluid shifts, endocrine shifts (which can result in decreased performance in flight), decreased postflight cardiovascular tolerance, and possible aggravation of latent diseases, will be carefully documented and, where feasible, prevented. To this end, specific operational requirements such as careful medical

selection, periodic evaluation of health status (including pre- and post-flight medical observation), in-flight monitoring of the time course of adaptation and performance in the space environment will be continually reevaluated and updated. Significant emphasis is placed on real-time testing of promising countermeasures developed by the research and analysis programs under controlled conditions.

The biomedical research program objective is to develop the basic medical knowledge needed to enable men and women to operate more effectively in space. The program is organized into discrete elements with each designed primarily to rectify a particular physiological problem expected to affect the human organism in prolonged or repetitive space flight. Thus, motion sickness, bone loss, and hormonal disturbances are the subjects of a continued search for countermeasures. The program is largely dependent upon the use of ground-based analogues of space flight. Special regimens of bed rest, water immersion, and centrifuge time are employed to evoke specific responses in both humans and animals. New techniques such as tomography and radionuclide imaging are being perfected to study these changes in living organisms.

The space biology activity will explore the role of gravity in life processes and use gravity as an environmental tool to investigate fundamental biological questions. Specific objectives are to: (1) investigate and identify the role of gravity in plant and animal cellular processes, embryonic development, morphology and physiology; (2) identify the mechanisms of gravity sensing and transmission of gravity perception information within both plants and animals; (3) identify the interactive effects of gravity and other stimuli (e.g., light) and stresses (e.g., vibration) on the development of metabolism of organisms; (4) use gravity to study the normal nature and properties of living organisms; and (5) extend the limits of knowledge about plant and animal growth and metabolism to provide for long-term survival and multigeneration reproduction of life in space. This program provides basic ground-based information in support of future space flight experiments and life support systems.

Exobiology is the study of the origin, evolution and distribution of life and life-related molecules on Earth and beyond. Sophisticated analyses of, life as we know it, its chemical precursors and its origin, coupled with extrapolation to extraterrestrial environments, afford a unique opportunity to address a most fundamental question regarding the existence of such processes beyond the Earth. Theories about chemical evolution and the origin of life are being refined to reflect results from the most recent planetary and astronomical explorations. The current research program also is uncovering an intimate association between the origin and evolution of life on Earth and the processes which shaped the evolution of the solar system itself. These discoveries have highlighted gaps in our knowledge which, when completed, will ultimately allow tests of the concept of universality of biological processes.

The life support systems research will focus on continuing research and development efforts aimed at enhancing our ability to support long-duration manned space occupancy, and maximizing astronaut and passenger-scientist productivity. Achievement of these goals is sought through improved habitability, and man-machine relationships, as well as provision of direct supportive needs such as food, water, and habitable atmosphere. The program will continue

to study the capability for generation and reuse of water and air for longer duration missions as contrasted to the expendable-type life support systems currently available.

CHANGES FROM FY 1981 BUDGET ESTIMATE:

The increase in the FY 1981 budget estimate is a result of additional Congressional appropriation for life sciences research and analysis. This funding will be utilized for the continuation of efforts in vestibular research and advanced life support systems.

BASIS OF FY 1982 ESTIMATE:

The operational medicine program will continue to investigate the possible occupational exposures in zero-gravity, and the development of training and remedial preventive measures, together with modification of medical care procedures utilized on Earth to meet the unique requirements of the space environment.

The biomedical research program will continue to focus primarily on the motion sickness problem because of its relevance to Shuttle operations. Cardiovascular and musculoskeletal studies will also be pursued in recognition of the considerable fundamental knowledge that must be acquired in these areas before effective countermeasures can be devised. Increased awareness and understanding of the radiation hazard has resulted in more emphasis being placed on the biomedical effects of high energy radiation and upon radiation protection. Major new avenues of modeling research will deal with the psychological accompaniments of space flight and with mathematical modeling procedures. As the duration of space flight increases, particular emphasis must be placed on the behavioral sciences.

The space biology program will continue to research the stress responses to hypo- and hyper-gravity and the relationship of these responses to those provoked by other stresses and stimuli. The use of gravity as a tool to investigate fundamental endocrine responses and basic biological control mechanisms will be expanded. The space biology program will continue to provide ground-based data for definition of future Shuttle/Spacelab flight experiments.

Exobiology research will concentrate on studies of the history of biogenic elements, the effect of -extraplanetary and astrophysical events on evolution of complex life and the distribution of life in the universe to try to make the scenario of life in the universe complete. Effort will continue on the definition and development of techniques to analyze extraterrestrial radio signals for patterns that may be generated by intelligent sources.

The life support systems program will continue to investigate basic biological processes and physical/chemical methods which will provide the capability to recycle waste, food, atmosphere and water.

SPACE AND
TERRESTRIAL
APPLICATIONS PROGRAMS

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1982 ESTIMATES

RESEARCH AND DEVELOPMENT BUDGET PLAN FOR SPACE AND TERRESTRIAL APPLICATIONS

<u>Programs</u>	Budget Plan			1982 Budget <u>Estimate</u>
	1980 <u>Actual</u>	1981 Budget <u>Estimate</u> (Thousands of Dollars)	Current <u>Estimate</u>	
Space applications.....	331,620	381,700	353,550	472,900
Technology utilization.....	<u>11,980</u>	<u>13,100</u>	<u>11,800</u>	<u>14,600</u>
Total... ..	<u>343,600</u>	<u>394,800</u>	<u>365,350</u>	<u>487,500</u>

SPACE
APPLICATIONS

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1982 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE AND TERRESTRIAL APPLICATIONS

SPACE APPLICATIONS PROGRAM

SUMMARY OF RESOURCE REQUIREMENTS

	1980	1981		1982	Page
	<u>Actual</u>	<u>Budget Estimate</u>	<u>Current Estimate</u>	<u>Budget Estimate</u>	<u>No.</u>
		(Thousands of Dollars)			
Resource observations.....	150,953	170,300	161,350	187,200	RD 7-9
Environmental observations.....	105,990	109,600	111,100	194,600	RD 7-31
Applications systems.....	24,567	18,100	18,100	14,400	RD 7-55
Technology transfer.....	10,087	7,500	10,100	9,000	RD 7-57
Materials processing in space.....	19,768	22,200	21,700	32,100	RD 7-60
Communications and information systems.....	20,255	29,000	31,200	35,600	RD 7-66
Total.....	<u>331,620</u>	<u>356,700</u>	<u>353,550</u>	<u>472,900</u>	
<u>Distribution of Program Amount by Installation:</u>					
Johnson Space Center.....	25,616	41,090	38,503	44,775	
Kennedy Space Center.....	508	180	110	170	
Marshall Space Flight Center.....	28,460	21,800	21,420	29,620	
National Space Technology Laboratories.....	3,190	2,175	3,060	2,750	
Goddard Space Flight Center.....	181,788	196,100	195,310	278,135	
Jet Propulsion Laboratory.....	24,999	19,870	22,630	40,250	
Wallops Flight Center.....	4,119	4,340	4,190	6,040	
Ames Research Center.....	16,560	17,250	17,937	12,535	
Langley Research Center.....	16,378	11,290	12,410	18,325	
Lewis Research Center.....	11,897	16,980	19,464	18,580	
Headquarters.....	18,105	25,625	18,516	21,720	
Total.....	<u>331,620</u>	<u>356,700</u>	<u>353,550</u>	<u>472,900</u>	

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1982 ESTIMATES

OFFICE OF SPACE AND TERRESTRIAL APPLICATIONS

SPACE APPLICATIONS PROGRAM

FLIGHT SCHEDULE

<u>Project</u>	<u>Mission</u>	<u>Calendar Year</u>
<u>Resource Observation</u>		
Earth Resources Technology Satellites	Launch of Landsat-D	1982
Shuttle/Spacelab Payload Development	Orbital Flight Test Missions Spacelab Payloads	1981 Beginning in 1984
<u>Environmental Observation:</u>		
Shuttle/Spacelab Payload Development	Orbital Flight Test Missions Spacelab Payloads	1981 Beginning in 1983
Earth Radiation Budget Experiment	Launch of ERBS ERBE instrument to be launched on NOAA F&G	1984 1983 & 1985 (subject to NOAA call-up)
Halogen Occultation Experiment	Launch on ERBS	1984
National Oceanic Satellite System	Launch of first spacecraft	1986
<u>Materials Processing in Space:</u>		
Materials Experiment Operations	Sounding Rocket Flight Flight of Shuttle Mid-deck Experiments	1981 Beginning in 1981
Shuttle/Spacelab Payload Development	Spacelab and Pallet Payloads	1984
<u>Space Communications:</u>		
Search and Rescue Mission	Instruments to be launched on NOAA-E, F, & G (TIROS-N series) spacecraft	1982, 1983, 1985 (subject to NOAA call-up)

<u>Project</u>	<u>Mission</u>	<u>Calendar Year</u>
<u>Reimbursable Missions:</u>		
GOES*	Launch of GOES E - F	1981 & 1983
NOAA*	Launch of NOAA C-G	1981 - 1985 (Subject to call-up by NOAA)

*National Oceanic and Atmospheric Administration (NOAA) funded.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1982 ESTIMATES

2 OF SPACE AND TERRESTRIAL APPLICATIONS

SPACE APPLICATIONS PROGRAM

PR OBJECTIVES AND JUSTIFICATIO

The object of the Space Applications program is to conduct research and development activities that demonstrate and transfer space-related technology, systems and other capabilities which can be effectively used for down-to-Earth practical benefits. These activities are grouped in the following general areas: resource observations, environmental observations, applications systems, technology transfer, materials processing in space, and communications and information systems.

In each of these areas, programs are being planned and conducted to contribute to the solution of pressing national, as well as international, problems and needs.

Resource Observations - This program addresses the needs for information of vital economic value to the United States and of worldwide humanitarian concern required for management of the world's limited food, water, and energy supplies, and for the identification of potential geological hazards. The principal objectives are to develop and demonstrate the use of space and space technology to provide the United States with a global capability for monitoring and forecasting major agricultural commodities, for water resources management, for land use assessment, for improving the exploration for mineral and energy resources, and for understanding the dynamic characteristics of the solid Earth and its crust, including tectonic plate motion, stability, and crustal deformation. Inherent in the pursuit of these objectives is the involvement of the users of space-derived information in the total program activities, from the planning to the development, test, verification, and application of the techniques.

Principal activities include the identification of user information needs, development of remote sensing and information extraction techniques, provision for the acquisition of space data, and joint research, development and test projects with users, leading eventually to the establishment and routine use of global data collection systems. Currently, Landsat-2 and -3 are providing a wide variety of useful data. Landsat-D, with improved sensing capabilities, is under development and will be launched in the third quarter of 1982. NASA will support the National Oceanic and Atmospheric Administration (NOAA) and its new responsibility for management of the operational land observing system. Experiments designed to test the applicability of active microwave measurements and high resolution imagery for mapping investigations are planned for flight on early Shuttle missions. Studies are also underway to define the Operational

Land Observing System (OLOS) to replace the Landsat-D based interim operational system in the 1990's, to define a solid state pushbroom scanner for improved services to the users in the operational era, and for improved remote sensors for multiple applications. Joint research, development, and testing activities with other Federal agencies are underway to advance our understanding of how to apply multiple data sources in improving agricultural early warning and crop commodity forecasting. Joint research activities are planned with other Federal agencies and coordinated with international organizations for advancing the scientific knowledge of the solid Earth.

Environmental Observation - Understanding the dynamics and limitations of our environment is essential to our long-term survival and to many of our day-to-day activities. Prediction of the weather, control of pollution, ship routing, storm warnings, and modeling of long-term trends in climate and in the stratosphere, are all areas where such understanding is put to day-to-day or strategic planning uses. NASA's environmental observation program aims at improving the understanding of processes, in the atmosphere and the oceans, providing space observations of parameters involved in these processes and extending the national capabilities to predict environmental phenomena and their interaction with human activities. Because many of these phenomena are global or regional in extent, they can be most effectively, and sometimes solely, studied from space. NASA's program includes research efforts plus the development, demonstration and transfer of new technology for global and synoptic measurements. NASA's research satellites give a special view of the radiative, chemical, and dynamic processes occurring in the atmosphere and oceans.

The environmental observations program includes studies and flight missions directed at all of the layers of the atmosphere from the highest layer of the upper atmosphere down to and including the upper layers of the oceans. The program areas include: (1) upper atmospheric research, (2) tropospheric air quality, (3) global weather, (4) severe storms, (5) oceanic processes (including ocean circulation, sea and glacier ice, coastal and inland waters, air-sea interaction and marine boundary layer), and (6) climate. This integrated approach encompasses the diverse fields of meteorology, climatology, atmospheric chemistry, atmospheric physics, and oceanography, and focuses on the special contributions of space-derived data.

Studies of the upper atmosphere are producing information on spatial and temporal distribution of ozone, are determining interaction among key processes, and are developing a strategy for comprehensive observations and monitoring. The processing of Nimbus Backscatter Ultraviolet (BUV) total ozone and upper stratosphere ozone data for the period 1970-1977 has been completed. We have also been able to separate biennial from annual trends and have derived ozone distributions as a function of the complex chemical system of the stratosphere. Advanced studies are underway and the instruments necessary for the next step in remote sensing of the upper atmosphere are being developed.

NASA's role in support of operational satellites, the NOAA and GOES series, is well established. TIROS-N, NOAA-A and GOES-D, launched from 1978 to 1980, continue to provide the NOAA with excellent data for incorporation into their forecasts. Nimbus-7 and SAGE continue to provide important research information. Several other flight programs, such as the Earth Radiation Budget Experiment, the Halogen Occultation Experiment and a number of Shuttle/Spacelab payloads,

are being prepared for launch in the early 1980's. Information from these experiments should provide a significant contribution toward achieving a better understanding of atmospheric processes and a basis for improved operational capabilities. Programs of research and transfer of technology are well established in the area of weather and storms.

Research and analysis of data from the flight demonstrations of remote sensing of the oceans have been a major thrust in recent years within the applied research and data analysis program. Based on experience gained through the Seasat mission and as a part of the ongoing program in remote sensing of the oceans, NASA, DOD, and NOAA are jointly developing the National Oceanic Satellite System (NOSS). To ensure the optimal use of this potential a NOSS research program will be initiated to modify the NOSS sensor payload; define the complementary in situ observations; and define an ocean data utilization system to allow the effective application of satellite data to ocean processes.

Applications Systems - This program supports space applications requirements for use of airborne facilities and provides flight support to major segments of the space applications programs as well as to other NASA programs.

Technology Transfer - The objectives of the technology transfer program are to understand the information needs of potential users of remote sensing technology in the public and private sectors and to provide for the transfer of applicable technology to meet these needs. •

Remote sensing technology developed by NASA is applicable to a wide range of resource management activities by potential users in all sectors of the economy. To ensure that this technology is matched to the requirements of these users, the information needs of these potential users must be assessed and updated periodically. The technology transfer program addresses these information needs through cooperative activities with user representative organizations such as the National Conference of State Legislatures (NCSL) and National Governors' Association (NGA). For remote sensing applications with matching information needs, validation is required to ensure that the technology is sufficiently developed to transfer to an operational user environment. This validation and transfer is accomplished in the regional remote sensing program and in the applications system verification program by joint projects with user organizations. Widespread dissemination of documentation on applicable technology for potential users in all sectors of the economy is effected through user organizations such as NGA and NCSL, and through NASA regional remote sensing centers at Goddard Space Flight Center, Ames Research Center and the National Space Technology Laboratories.

Materials Processing in Space - The materials processing in space (MPS) program emphasizes the basic and applied science and technology of processing materials under conditions that allow detailed examination of the constraints imposed by gravitational forces. The goal is to develop, test, and demonstrate the capabilities of spaceborne facilities for materials processing in the space environment, and to provide opportunities for independently-funded users to exploit space flight for processing activities related to their own needs. In accordance with guidelines formulated and published in 1979, negotiations on several joint endeavors with private companies will be conducted in 1981-1982. These activities are intended to encourage early transfer of space activity in materials science to private

sponsorship. Ground-based research in FY 1982 will accommodate new areas of interest in materials science and in physical and chemical sciences as well as advanced technology development to meet needs identified in the research program. Development of the program's first space transportation system (STS) payload equipment will be completed in FY 1981, leading to flight in the second half of N 1981.

Communications and Information Systems - Telecommunications and information systems technology is a recognized indicator of the state of development and economic health of a country. While this country has led the world in these technologies, we are now being challenged by Japan and several European countries. NASA has re-established itself as a leader and partner with United States industry to plan and execute a high technology program characterized by focused technology development at the component level and selected demonstrations of these technologies at the system level. NASA is also identifying and providing those technologies needed by other Federal agencies to carry out their missions. NASA has initiated a strong program in data systems to provide the focus, direction, and technology to handle the proliferation of raw data originating from satellite and terrestrial sensors. Success of the NASA program will be measured by the preeminence of United States industry in the world marketplace; by new and enhanced services provided to the public at low cost; by new and useful information made available to the public and business through improved data systems; by better government services to the public such as emergency communication; and new products, services and business opportunities for markets at home and abroad.

CHANGES FROM FY 1981 BUDGET ESTIMATE:

The current estimate for the FY 1981 program is \$3.15 million below the budget estimate, the net result of specific adjustments made to the program by the Congress, and the overall Congressional reduction to the NASA appropriations request.

There have been no major redirections in the N 1981 program. However, funding adjustments have been made in three projects, related to the reallocation of funding required in N 1980 for the Landsat-D project. The FY 1981 estimate for Landsat-D has been decreased by \$5.8 million in order to restore funds to the Earth radiation budget experiment (\$3.3 million) and the search and rescue mission (\$2.5 million) which were reallocated to Landsat-D in FY 1980.

In its action on the N 1981 NASA budget request, the Congress recommended increased emphasis in three areas of the applications program: operational land observing, technology transfer, and materials processing. Due to the overall net decrease in the appropriation, and the need to maintain program balance, it has not been possible to fully implement the proposals. However, the Agency's current plan for FY 1981 does include advanced technology development on the multilinear array instrument and continued definition studies in support of the transition to an operational land observing system. In addition, increased funding is being applied to the technology transfer program.

Finally, minor changes have been made to the space applications budget structure. The title of space communications has been changed to communications and information systems **so** as to be more descriptive of its total content. Within communications and information systems, the data management and ADS definition studies projects have been combined into a single project titled data systems program, and follow-on data analysis and operations has been changed to experiment coordination and operations support.

BASIS OF FY 1982 FUNDING REQUIREMENTS:**RESOURCE OBSERVATIONS**

	1980	1981		1982	Page
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>	<u>No.</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>	
		(Thousands of Dollars)			
Landsat-D.....	104,413	94,300	88,500	83,900	RD 7-14
Magnetic field satellite	1,600	500	500	---	---
Extended mission operations.....	1,904	2,700	2,700	2,800	RD 7-16
Shuttle/Spacelab payload development.. ..	2,031	2,000	2,000	2,300	RD 7-18
AgRISTARS.....	16,000	33,200	31,450	33,100	RD 7-20
Applied research and data analysis.....	12,405	12,800	12,800	23,200	RD 7-22
Coastal	12,600	24,800	23,400	31,900	RD 7-26
Geological applications program.....	---	---	---	10,000	RD 7-29
Total.....	<u>150,953</u>	<u>170,300</u>	<u>161,350</u>	<u>187,200</u>	

OBJECTIVES AND STATUS

The goals of the resource observation program are to assist in solving Earth resources problems of national and global concern through the development and application of space technology and techniques, and to conduct research and observations to improve our understanding of the dynamic characteristics of the Earth. The ultimate aim of the resource observation program is the development and transfer of remote sensing techniques to the users--federal agencies; State, regional and local government; private industry; and the scientific community--where these techniques enhance or supplant existing capabilities or provide a new capability in an effective manner. This is accomplished by developing and applying space observation techniques to meet national and global needs for improved management of food, fiber, water, and land resources; improving our ability to systematically evaluate the composition and geometry of the Earth's crust in order to increase the effectiveness of global assessment, exploration, and development of mineral and energy

resources; increasing our understanding of the solid Earth, its interior structure and composition, its rotational dynamics, the processes related to the movement and deformation of its crust, and the mechanisms associated with the occurrence of earthquakes; and, developing and transferring the technology to the responsible user organizations, leading to an evolutionary development of a global space-sensing capability for the routine dissemination and use of timely and comprehensive land resource information.

Principal elements of the program include the development of space and supporting ground systems and improved data processing and analysis techniques; Shuttle and aircraft support for sensor and technique development; and basic and applied research for identifying, monitoring, analyzing, and modeling the vegetated and geological features of the Earth.

Landsat-2 has resumed operations following a six-month hiatus from January to June 1980 due to a locked yaw-axis reaction wheel that made fine pointing for data acquisition impossible. Following a series of tests, the frozen reaction wheel was freed and the spacecraft is now stable and acquiring high quality Multispectral Scanner (MSS) data. Both wideband tape recorders on Landsat-2 and one of the two tape recorders on Landsat-3 have failed; a contingency plan has been developed to put recorders in selected ground receiving stations in order to assure collection of Multispectral Scanner imagery of foreign areas required for key United States agricultural and other research programs. All the backup units will be in place by mid-1981. In addition, a transportable ground station is being developed for deployment in late 1982.

The onboard data handling unit for the Landsat-3 Multispectral Scanner failed in December 1980 and useful data are no longer being acquired. The Return Beam Vidicom (RBV) system is operating nominally and providing high quality pan-chromatic imagery. Both wideband tape recorders on Landsat-3 are operational with RBV data providing a worldwide coverage capability.

Landsat-D development is proceeding, with the launch of Landsat-D planned for the third quarter of 1982. Landsat-D will incorporate both the Thematic Mapper (TM) and Multispectral Scanner; however, the launch will not be delayed for a late delivery of the TM. Landsat-D', the backup spacecraft, will be available for launch 12-15 months later. In addition to continuing the availability of MSS data, Landsat-D will provide imagery with the improved spectral and spatial resolution of the TM needed to expand the use of space data for agricultural, water resources, land use, and other applications.

The Thematic Mapper engineering model is in the integration and test cycle and is scheduled to be delivered by the contractor, Hughes Aircraft Company, in March 1981. The protoflight model Multispectral Scanner has been integrated and is now undergoing a series of environmental tests before its delivery in January 1981. The major

accomplishments by the mission contractor, General Electric, during FY 1980 included completion of the flight segment design, completion of antenna model testing, and fabrication and structural and dynamic testing of the mechanical test model. The ground segment design has been altered to incorporate separate processing systems for the TM and MSS to reduce development risk. Most of the equipment for the Landsat-D ground system has been delivered and the integration of the systems and software development is underway.

In FY 1980, advanced systems studies focused on a new generation of land remote sensing instruments utilizing the solid state Multilinear Array (MLA) technology planned for eventual use in the NOAA-operated Operational Land Observing System (OLOS) in the late 1980's and into the 1990's. Activity in FY 1981 will focus on developing several sensor design approaches including focal plane technology development for the shortwave infrared region, and development of data processing techniques and system. The advanced technology development in FY 1982 will focus on continued development of focal plane array technology for the shortwave infrared region, and will support the definition of a solid state instrument for the mid-1980's. The technical definition studies of the fully operational OLOS will be performed in FY 82 and FY 83.

Improvements in the effectiveness of exploration for new mineral and energy deposits require the development of a global capability for efficiently determining the composition and structure of the Earth's crustal materials. Remotely-sensed data in the visible, infrared, and microwave portions of the spectrum are useful for these purposes, but currently performing systems are somewhat limited in their contributions. New instruments, such as the Shuttle Multispectral Infrared Radiometer (SMIRR), the Shuttle Imaging Radar (SIR-A), and the Large Format Camera (LFC) are being developed to obtain, on an experimental basis, additional narrow-band infrared, microwave, and high resolution panchromatic stereo imagery which will be assessed for its applicability in aiding in resource assessment and exploration. Development of the SIR-A, and SMIRR, and the ocean color experiment, which is designed to determine areas of phytoplankton concentration, has been completed, and the instruments have been integrated with the Shuttle pallet for flight in late 1981. These instruments will provide new and unique data for studying terrain features and discriminating among rock types. Development of the large format camera is proceeding on schedule. It will be flown on a Shuttle flight in 1984 and is expected to obtain important imagery for improving current mapping techniques.

The Heat Capacity Mapping Mission was successfully completed in 1980 after two and one-half years, and the data are now being analyzed to determine their utility in discriminating the composition of crustal materials, in meteorological applications, and in agricultural planning.

Magsat, launched on October 30, 1979, completed its planned mission in mid-June 1980. All the measurement goals were exceeded and the data quality was better by a factor of three than the original goal. An initial definitive magnetic field model has been provided to the prime user, the United States Geological Survey, for use in developing maps and charts which are published and issued to the public for navigation and exploration. Considerable data collection at altitude; well below 200 km will make it possible to identify new magnetic anomalies and better resolve previously known ones. Scientific studies using these data are underway.

A major aspect of the resource observation program is the research associated with understanding the physical relationship of various types of vegetation and other surface features with the radiation which they emit or reflect; with the development of models appropriate to the management of resources; and, with the evaluation of the use of space-derived data along with other data sources in meeting user needs. The scope of these activities ranges from individual scientific studies to projects such as the agriculture and resources inventory surveys through aerospace remote sensing (AgRISTARS).

AgRISTARS was initiated in FY 1980, with the Department of Agriculture, NOAA, and NASA as principal participants to address priority information needs identified by the Department of Agriculture. The Department of Agriculture information requirements cover a select group of crops and producing countries of significance to world trade and world nutrition. In 1980, an improved technique was developed for estimating the area planted in specific crop types over large geographic areas. The improved methods were successfully tested in exploratory experiments involving wheat and barley crops in the United States Great Plains, and corn and soybean acreage in the Corn Belt. These results will lead to pilot experiments for predicting crop production in foreign countries.

When the results of the research indicate a potential application, application pilot tests (APT's) are used to test and expand the research concepts in the realism of the users' environment. Three APT's were successfully completed this year. One test resulted in the development of an operational forest resource information system by the St. Regis Paper Company, based on Landsat MSS data, which will soon be implemented by that company. Cooperation between NASA and the Navajo Indian Nation produced an automated information system which utilizes remotely-sensed data for the management of natural resources on the Navajo Reservation. On the basis of another APT, the Bureau of Land Management (BLM) established a remote sensing branch and implemented a data analysis system for monitoring the wildland areas under BLM management. Each of these tests demonstrate the progression from remote sensing research and development to operational utilization of the technology by a cooperating resource manager. In FY 1981 two APT's will be completed: an urban area information system with the Bureau of the Census; and an automated crop area information system with Cotton, Inc. Four application pilot tests will continue with the California Department of Water Resources, the Pennsylvania Department of Environmental Resources, the Missouri Farm Association, and the United States Geological Survey.

Studies of the movement and deformation of the Earth's crust, the rotational dynamics of the Earth, and the Earth's gravity and magnetic fields provide information needed to understand the processes leading to the release of crustal strain in the form of earthquakes, to improve our understanding of the formation of mineral deposits, to contribute a long-term weather and climate forecasting, and to better understand the Earth as a planet. Space techniques (laser ranging to satellites and the Moon, very long baseline interferometry--VLBI--using radio stars or satellites, and satellite mapping) are the only methods which can provide the precise measurements needed for these studies. In FY 1980 and 1981, measurements of the relative motion of several of the tectonic plates which form the Earth's crust, and of regional crustal deformation in California were initiated. Variations in the Earth's polar motion were monitored and

correlated with changes in the angular momentum of the Earth's atmosphere resulting from shift in atmospheric winds. Laser and **VLBI** measurements of Earth rotational dynamics were intercompared with satellite Doppler and conventional techniques in an international campaign under the auspices of the International Astronomical Union (IAU). Requirements for global field surveys were determined and conceptual studies of an Earth gravity field survey mission were completed. The NASA geodynamics program is conducted jointly with the National Oceanic and Atmospheric Administration, the United States Geological Survey, the National Geodetic Survey and the Defense Mapping Agency through an interagency agreement for the application of space technology to crustal dynamics and earthquake research. In FY 1982, the regional crustal deformation studies will be extended to most of the western portion of the United States; the tectonic plate motion and plate stability studies will be continued.

The major new FY 1982 thrust of the resource observations program is the Geological Applications Program (GAP). **This** program's goal is to improve the effectiveness of global assessment, exploration, and development of mineral and energy resources through the use of space techniques. The specific objectives are to develop remote sensing methods for systematic geologic mapping on a global basis, and to develop improved geological models which employ space-acquired data for resource evaluation and development.

EARTH RESOURCES TECHNOLOGY SATELLITE (LANDSAT-D)

	1980	1981		1982
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of Dollars)		
Spacecraft systems and sensors.....	83,413	60,000	71,400	44,400
Ground system.....	20,900	34,300	17,000	27,600
Ground operations.....	---	---	---	8,500
Investigations.....	100	---	100	3,400
Tal.....	<u>104,413</u>	<u>94,300</u>	<u>88,500</u>	<u>83,900</u>
Delta (expendable launch vehicles program).....	(10,000)	(6,000)	(9,600)	(3,300)

OBJECTIVES AND STATUS:

The objectives of the Landsat-D project are to develop, launch, and operate an advanced land observing system and to assess and demonstrate the utility of satellite-based Earth resources remote sensing systems with the new experimental Thematic Mapper (TM) and the flight-proven Multispectral Scanner (MSS). The Landsat-D launch is now planned for the third quarter of 1982 as a result of a program rebaseline to overcome technical and management problems. The backup spacecraft, Landsat-D prime, will be available for launch 12-15 months after the initial launch. The major technical focus of the Landsat-D project involves a test of both the TM instrument's capabilities and an improved ground data handling system. The TM, on which development was initiated in FY 1977, will offer higher resolving power and greater spectral coverage than existing instruments. These advantages promise to open up a significant number of new uses of Landsat data and to enhance many current uses.

The MSS contract was awarded in March 1978, and the design changes necessary for the Landsat-D mission have been verified by ground tests. Activities on the protoflight and flight model are on schedule for delivery to the mission contractor in early and mid-1981, respectively.

The present TM schedule points to an October 1981 delivery of the protoflight unit to the mission contractor for spacecraft integration, which is consistent with a third quarter 1982 launch of Landsat-D. Under the rebaselined program however, launch of Landsat-D will not be delayed for late delivery of the TM. If schedule delays occur in the TM development such that the Landsat-D launch schedule cannot be met, the TM will not be flown until the launch of Landsat-D prime.

Work is continuing on schedule for the Multimission Modular Spacecraft (MMS). The integrated spacecraft bus is scheduled to be delivered to the Landsat-D mission contractor in March 1981. The mission-unique flight segment design is completed, and the mechanical test model of the spacecraft has undergone successful deployment tests of the solar array and communication system antenna; vibration tests of the structure have also been completed. The communication system development testing has been completed and the communication system flight hardware is being assembled.

The ground segment design approach has been altered to reduce development risk. Various hardware elements such as the high density tape recorders and data processing control computers have been delivered during FY 1981. Overall hardware and software development for the reconfigured ground system is on schedule to support the new readiness dates.

CHANGES FROM FY 1981 BUDGET ESTIMATE:

The net reduction of \$5.8 million in the Landsat-D project in FY 1981 is the result of a rephasing of funding between FY 1980 and FY 1981 to support higher funding requirements in FY 1980 than planned for the instruments and the spacecraft during critical periods of their development. Technical problems caused a delay of approximately one year in the planned launch of the mission, which in turn resulted in the funding adjustments among the project elements in FY 1981. The current total cost estimate for the Landsat-D project is \$500-550 million.

BASIS OF FY 1982 ESTIMATE:

FY 1982 funds will permit the completion of integration of the MMS, MSS, TM, and the mission-unique subsystems in support of the third quarter 1982 Landsat-D launch date. FY 1982 funds will also permit integration of the TM to be flown on Landsat-D prime. The Landsat-D ground system, including the operations control center and MSS data processing system, will move into the integration test phase to insure its readiness to support the launch of Landsat-D.

EXTENDED MISSION OPERATIONS

	1980	1981		1982
	<u>Actual</u>	<u>Budget</u> <u>Estimate</u>	<u>Current</u> <u>Estimate</u>	<u>Budget</u> <u>Estimate</u>
		(Thousands of Dollars)		
Heat capacity mapping mission.....	600	300	300	---
Landsat-2 and -3.....	1,304	2,400	2,215	2,575
Magnetic field satellite.....	---	---	185	225
Total.....	<u>1,904</u>	<u>2,700</u>	<u>2,700</u>	<u>2,800</u>

OBJECTIVES AND STATUS:

The objective of extended mission operations is to capitalize on the continued performance of the Landsat and other Earth resource observation satellites beyond the initially planned mission duration. Data products from these missions are being used to support research and operational activities in agriculture, water resources, geology and land use. In the case of Landsat, some operational requirements of Federal and State agencies, plus many private interests are now being satisfied. It is essential that Landsat operations continue up to the launch of Landsat-D to assure continuity of data for these user activities.

Landsat-2 is currently operating and providing data, although at reduced operational levels. The frozen momentum wheel, which resulted in the loss of Landsat-2's stable attitude control in November of 1979, responded to continued attempts to free it in May 1980, and the spacecraft was returned to operational status on June 6, 1980. The spacecraft is now stable in all three axes and is returning high quality data to domestic and foreign receiving stations when within their ranges. Both Landsat-2 onboard video tape recorders are inoperative, however, limiting its data return mode to real-time operations. A backup plan is being implemented to install ground recording equipment in selected foreign stations to assure Multispectral Scanner coverage for key agricultural programs.

The onboard data handling unit for the Landsat-3 Multispectral Scanner (MSS) failed in mid-December, 1980. No useful data are being acquired by the MSS. The return beam vidicon continues to operate nominally and is providing high quality panchromatic imagery. Both onboard tape recorders are operational with RBV data, providing a worldwide coverage capability.

There are now ten ground receiving stations operating in nine foreign countries, in addition to three in the United States.

CHANGES FROM FY 1981 BUDGET IMATE:

The current FY 1981 estimate reflects a minor adjustment in funding requirements between missions to allow for continuing analysis of Magsat data, resulting from the longer-than-planned mission life of the satellite.

BASIS OF FY 1982 ESTIMATE:

The requested FY 1982 funding level will support the continuation of remotely-sensed multispectral and high resolution panchromatic imagery of the Earth's surface from Landsat-2 and -3 for both research and development and operational users; and for the completion of the data processing from the Magsat mission. These data will be applied to agricultural, forestry, water and land management, and geological studies.

SHUTTLE/SPACELAB PAYLOAD DEVELOPMENT

	1980	1981		1982
	<u>Actual</u>	<u>Budget</u> <u>Estimate</u>	<u>Current</u> <u>Estimate</u>	<u>Budget</u> <u>Estimate</u>
		(Thousands of Dollars)		
Orbital flight test payload development.....	854	800	1,800	1,900
Large format camera.....	<u>1,177</u>	<u>1,200</u>	<u>200</u>	<u>400</u>
Total.....	<u>2,031</u>	<u>2,000</u>	<u>2,000</u>	<u>2,300</u>

OBJECTIVES AND STATUS:

The objective of this project is to develop, test, demonstrate, and evaluate Earth-viewing remote sensing instruments and systems to obtain data for resource observations research. Three instruments have been completed and integrated with the OSTA-1 pallet at the Kennedy Space Center and are awaiting flight on the second Shuttle mission, STS-2, in the summer of 1981. Development of the large format camera is complete. It has been accepted from the manufacturer, and is in storage at the Johnson Space Center pending flight on OSTA-3 in the 1984 time frame.

The Shuttle test flight instruments are: the Shuttle Imaging Radar (SIR-A), for evaluation of the applicability of spaceborne imagery radar for geologic exploration; a Shuttle Multispectral Infrared Radiometer (SMIRR) to conduct research for optimum spectral bands for geologic mapping; and, an ocean color experiment scanner to assess the applicability of improved passive, color sensing techniques for mapping biologically-rich (phytoplankton) area in the ocean. The SIR-A is an adaptation of the Seasat synthetic aperture radar and will be the first use of spaceborne radar specifically for landform analysis. The Large Format Camera is a high resolution mapping camera with direct application to the mapping of large geographic areas for cartographic purposes and for mineral and energy resources exploration. The Large Format Camera Interagency Working Group meets periodically to review camera design, evaluate pre-mission camera performance data, and determine initial mission coverage requirements; it will also prepare a post-flight data usefulness and system performance report.

Included in the overall project plan is the design and fabrication of a Synthetic Aperture Radar (SAR) with fold and tilt antenna capability for reflight of SIR-A in the 1984 time frame. This fold and tilt capability is fundamental to reducing the payload volume required for future spaceborne radar flights and will provide selectable depression angles for the SAR. In addition, the SMIRR will be refurbished after its flight on OSTA-1 for reflight in 1984 on OSTA-3.

CHANGES FROM FY 1981 BUDGET ESTIMATE:

The changes between instruments in Shuttle/Spacelab payload development activities in FY 1981 result from stretchout in the OSTA-1 program and a slowdown on the Large Format Camera program to be consistent with revised Shuttle flight schedules.

BASIS OF FY 1982 ESTIMATE:

During FY 1982, the Large Format Camera will be maintained in storage, and preparations for flight on the Shuttle of the OSTA-3 payload (LFC and SMIRR) and SIR-A reflight in mid-1984 will be continued. The data from the flight of OSTA-1 will be processed and analyzed for geological information. The SIR-A antenna will be modified to incorporate a fold mechanism for more efficient utilization of the available volume in the Shuttle payload bay and a tilt mechanism will be added to allow variation in antenna depression angle during data acquisition. Systems spares will be procured for the LFC, and design of LFC ground operations hardware for the Payload Operations Control Center will be initiated.

Agriculture and Resources Inventory Surveys Through Aerospace Remote Sensing (AgRISTARS)

	1980	1981		1982
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of Dollars)		
Foreign commodity production forecasting	6,800	13,200	13,000	10,000
Supporting research.....	7,000	13,800	13,400	13,800
Early warning, soil moisture, domestic crop and land use, conservation, pollution, and renewable resources.....	<u>2,200</u>	<u>6,200</u>	<u>5,050</u>	<u>9,300</u>
Total.....	<u>16,000</u>	<u>33,200</u>	<u>31,450</u>	<u>33,100</u>

OBJECTIVES AND STATUS:

The goal of the AgRISTARS program is to determine the extent to which aerospace remote sensing data can be efficiently integrated into existing or future United States Department of Agriculture (USDA) systems to improve the objectivity, reliability, timeliness, and adequacy of information required to carry out USDA missions. The near-term objectives are to develop and test remote sensing analysis techniques which address USDA information needs in early warning of various environmental changes affecting production and quality of commodities and renewable resources, commodity production forecasts, land use classification and measurement, renewable resources inventory and assessment, land productivity estimates, conservation practices assessment, and pollution detection and impact evaluation. The early warning and commodity production forecast effort is focused on foreign crop/countries for which USDA has poor production estimates. Exploratory tests have been completed for wheat and barley in the United States Great Plains and Canada, and for corn and soybeans in the United States Corn Belt. Exploratory tests for wheat in Australia; corn/soybeans in Brazil; and wheat, corn, soybeans in Argentina are continuing. Changes in program phasing have been made to accommodate a rescheduling in the availability of Thematic Mapper (TM) data to October 1983 consistent with the current Landsat-D launch schedule, and to accommodate a possible Multispectral Scanner data gap in 1982. This resulted in lengthening the program from six to eight years in the areas of supporting research and foreign commodity production forecasting.

CHANGES FROM FY 1981 BUDGET ESTIMATE:

The reduction of \$1.75 million is due an overall reduction by Congress to the NASA appropriations request. Experiment design and research activities in the foreign commodity production forecasting project and development of information

extraction techniques have been delayed to reflect the impact of the delay of Landsat-D thematic mapper data availability and a possible Multispectral Scanner data gap in 1982.

BASIS FOR FY 1982 ESTIMATE:

Major FY 1982 milestones for foreign commodity production forecasting involve technique development and evaluation for crop identification, crop development stage, and crop area and production estimation. These major milestones include: completion of initial technique development for advanced machine processing procedures employing Landsat data for area estimation of United States corn/soybeans; completion of initial data collection and research for development of advanced digital processing procedures for area estimation of United States/Canada wheat/barley; completion of a wheat/barley separation procedure test over a limited region for USSR barley; completion of forecasting technique development for Brazil corn/soybeans; completion of forecasting technique development, design of a technique a evaluation experiment, and initiation of data acquisition for Argentina wheat/corn/soybeans; and, completion of technique development for Australia wheat and data acquisition for FY 1983 testing of the technique.

Major FY 1982 activities under supporting research include: TM information extraction technique development using TM simulator data for improving the accuracy of area estimation; development of preliminary advanced area estimation technology which merges improved statistical sampling techniques with improved sample analysis for large area inventories; development of improved crop spectral identification procedures based on research initiated in FY 1981; improving registration for multisensor data applications to crop identification; and using TM simulator spectral data to improve estimates of crop development stage and to improve responsiveness of yield models to spectral inputs.

Applied Research and Data Analysis (Resource Observations)

	1980	1981		1982
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of Dollars)		
Renewable resources.....	5,500	4,100	2,850	4,400
Nonrenewable resources.....	3,300	3,900	3,300	5,000
Application pilot tests.....	1,160	1,400	1,050	1,500
Operational Earth resources system definition.....	1,100	1,800	600	2,000
Multilinear array advanced technology development.....	---	---	4,300	8,500
Advanced studies.....	<u>1,345</u>	<u>1,600</u>	<u>700</u>	<u>1,800</u>
Total.....	<u>12,405</u>	<u>12,800</u>	<u>12,800</u>	<u>23,200</u>

OBJECTIVES AND STATUS:

The goal of the applied research and data analysis (AR&DA) activities is to develop, through theoretical studies, ground-based research and aircraft instrument development, remote sensing capabilities that can aid in the management of renewable and nonrenewable resources and monitor the impact of man and his works on the natural environment; and to perform the advanced technology development and detailed system definition studies required prior to initiation of new space flight hardware development. This program supports the ground-based and aircraft-based activities for renewable and nonrenewable observations research; system definition studies of flight hardware sensors and missions in renewable and nonrenewable resources and in geodynamics; advanced technology development required to implement new sensors and missions and feasibility and conceptual design studies of future sensors and missions.

The overall objectives of this effort are: to improve machine-aided interpretation and classification and data handling techniques, which are needed to increase efficiency in transforming space-derived data into information for utilization by the user community; to test this capability with the users through applications pilot tests; to analyze user requirements for new types of space-acquired data; to develop and demonstrate ground-based or airborne systems that are derived from space technology; to perform feasibility, conceptual design, and detailed systems definition studies of new sensors and missions; and to perform the advanced technology development necessary to implement these new sensors and missions.

The specific objectives in renewable resources are to extend and strengthen the fundamental understanding of the remote sensing process, to evaluate improvements to land cover inventory and monitoring resulting from use of the thematic mapper, thermal infrared, and passive and active microwave data; to develop improved ground and aircraft microwave sensors and data processors; and to conduct joint user tests (applications pilot tests) which apply these techniques in an operational setting.

The specific objectives in nonrenewable resources are to develop techniques for extracting useful geological information from remote sensing measurements; to employ remote sensing techniques in unique and innovative ways; to develop improved geological models; and to experimentally evaluate the utility of remote sensing methods for specific geological applications.

The objective of application pilot tests (APT) is to develop and test research-proven remote sensing techniques jointly with users in operational applications. Three **APT's** were successfully completed in FY 1980 and resulted in operational implementation of Landsat digital processing systems. These included a Landsat-based automated resources inventory system for the Navajo nation, a wildland vegetation resources inventory system with the Bureau of Land Management, and a forest resources information system with the Southern Timberlands Division of the St. Regis Paper Company. An automated cotton acreage inventory system with Cotton, Incorporated, is scheduled for completion in FY 1981.

The objective of the advanced study activity is to perform feasibility and conceptual design studies of future sensors and missions in order to ensure the conceptualization of high priority future capabilities in remote sensing of Earth resources.

The objective of the operational Earth resources system definition activity is to support NOAA in its newly assigned responsibility for the future Operational Land Observing System (**OLOS**). Activities in FY 1982 include conceptual definition of **OLOS** including a top-down total system architecture and its modes of operation, an analysis of data acquisition requirements, and identification of implementation options. In FY 1980, a survey of potential user requirements for space-acquired data in the mid-to-late-1980's and an analysis of these data were performed; a preliminary feasibility study of the space and ground segments was initiated. In FY 1981 system conceptual design studies will be initiated and user technical requirements and system specifications established.

In FY 1981, a program will be initiated to develop the technology to support the conceptual design and future engineering development of a Multilinear Array (**MLA**) instrument for the next generation remote sensing system. The **MLA** solid state sensor will ultimately provide improved services to the user and new land remote sensing capabilities for the civil operational land observing system in the late 1980's. The **MLA** solid state sensor uses electronic scanning (pushbroom mode). Fundamental advantages are improved spectral and spatial resolution; improved registration and geometric fidelity; greater sensitivity; and the capability for selective spectral bands, resolution, and swath width.

Solid state technology is being exploited in French and Japanese satellite developments. This advanced technology development program will provide a base for maintaining United States leadership in this critical area. These advanced technology development activities include the development of the shortwave infrared detector focal plane array, considered the pacing item in the MLA technology development, and a definition study for an MLA instrument to provide the basis for instrument design specification. These activities will be continued in FY 1982.

CHANGES FROM FY 1981 BUDGET ESTIMATE:

Reallocation of funding within the AR&DA activity was required in order to initiate the MLA technology development and study efforts in FY 1981 as requested by the Congress.

BASIS OF FY 1982 ESTIMATE:

Renewable Resources: The FY 1982 budget is based on continuation of research in land resources remote sensing techniques development, fundamental remote sensing investigations, and processing technique development.

Nonrenewable Resources: Planned research will extend into other portions of the electromagnetic spectrum, specifically concentrating upon the thermal infrared and microwave regions. Measurement capabilities from aircraft platforms will be expanded and upgraded with the fabrication of a six-channel multiband thermal infrared scanner, and the development of digital data recording systems for airborne radars. Optical processing of Seasat synthetic aperture radar data over land areas will be completed. Initial developments of new techniques will commence in FY 1982, concentrating upon fluorescence methods, laser remote sensing, and long wave length electromagnetic sounding techniques. Small scale test projects will be initiated to investigate potential new applications of space technology concerned with engineering geology, environmental impact of resource development, and geologic hazards analysis.

Applications Pilot Tests: In FY 1982 four APT's will continue with the Pennsylvania Department of Environmental Resources, the Missouri Farm Association, the California Department of Water Resources, and the United States Geological Survey. Three new APT's will be initiated which will test the use of the thematic mapper using aircraft data derived from the thematic mapper simulator.

Operational Earth Resources Satellite Definition: The FY 1982 funds will be used to initiate competitive contractor supported studies to define the operational land observing system.

Multilinear Array (MLA) ATD: FY 1982 funds will support instrument definition and the shortwave infrared detector and focal plane array studies in support of the MLA solid state sensor development. The instrument definition studies include conceptual design of the solid state sensor instrument with emphasis on focal plane data processing, onboard data processing, focal plane microcircuitry, data compression, data storage, and data transmission techniques. These

studies will be evaluated and specifications for an MLA instrument derived from this effort. The shortwave infrared detector and focal plane array activities will include the development of detector materials, focal plane microcircuitry and arrays, on-focal-plane data processing, cooler technology, and readout techniques. Effort will also be undertaken to define the ground data processing facility required to handle the increased data rates and throughput demands for the next generation land remote sensing system.

Advanced Studies: Planned studies of potential future sensors and high priority missions for remote sensing of Earth resources will be continued. Studies on the feasibility of the techniques will be performed as part of the renewable and nonrenewable research activity; conceptualization of the sensors and the missions will be accomplished in the advanced study effort. Studies to be performed in FY 1982 include continuation of the advanced study for the Graysat mission, a land observing radar research mission, a thermal infrared mapping mission, and a digital topographic mapping sensor and mission.

Geodynamics

	<u>1980</u> <u>Actual</u>	<u>1981</u> Budget <u>Estimate</u> (Thousands of Dollars)	Current <u>Estimate</u>	<u>1982</u> Budget <u>Estimate</u>
Crustal dynamic project.....	9,600	12,600	11,570	17,300
Laser network operations.. .. .	(8,400) *	9,000	8,630	12,400
Research and technique development.....	<u>3,000</u>	<u>3,200</u>	<u>3,200</u>	<u>2,200</u>
 Total.....	 <u>12,600</u>	 <u>24,800</u>	 <u>23,400</u>	 <u>31,900</u>

*Funding responsibility transferred from Space Tracking and Data Systems to Space Applications in FY 1981; FY 1980 funding not included in totals.

OBJECTIVES AND STATUS:

The geodynamics program makes use of the unique capabilities provided by space techniques to improve our understanding of the dynamic processes occurring within the Earth and on its surface. The objectives of the program are to verify and extend tectonophysical theories by measuring the contemporary motions of the plates and determining the plate-driving forces; to contribute to studies of earthquake mechanisms by measuring and modeling crustal deformation at active plate boundaries; to study causative relationships between variations in the Earth's polar motion and rotational rate with earthquake occurrences, internal core dynamics, and other physical phenomena; and to map and model the global gravity field for studies of crustal processes associated with the formation of mineral and petroleum deposits, for studies of the internal composition and structure of the Earth, and for studies of oceanic circulation and current systems.

The distance measurement techniques are based on laser ranging to satellites and the Moon and on a Very Long Baseline Microwave Interferometry (VLBI) using signals from radio stars or, in the future, telemetry from the global positioning system satellites. These techniques also provide information on the Earth's polar motion and rotational rate. The Earth's gravity field is deduced from the perturbation of satellite orbits using telemetry or laser tracking from the ground or using satellite-to-satellite tracking.

The crustal dynamics project supports the development of laser ranging and VLBI systems for measurement of plate motion, plate stability, regional crustal deformation, polar motion, and Earth rotation. The project is expected to

contribute to understanding why and how earthquakes occur and perhaps to the development of earthquake prediction methods. The project activity is conducted jointly with NOAA, USGS, NSF, and **DMA**, through an interagency agreement for the application of space technology to crustal dynamics and earthquake research. In February 1980, an agreement was concluded with Japan for joint VLBI experiments in 1983 using a VLBI station to be developed by Japan at the Radio Research Laboratories at Kashima. The laser network operations supports operations and data processing for mobile lasers in the United States, the Pacific, South America, and Australia.

In a continuing effort to verify the accuracy of laser ranging and VLBI, lasers were located in 1980 at sites on the East and ~~West~~ Coasts and in Texas. The data, which are now being analyzed, are expected to show agreement over the 4,000 km baseline to ± 5 cm. In 1980, mobile lasers were also located on several islands in the Pacific and in California. Observations were also made with VLBI stations in the United States, Germany, Sweden, and England. **As** a result, initial baselines have been obtained for locations on the Pacific, North American, Australian, South American, and Eurasian Plates. These observations will be repeated once or twice each year to obtain information on plate velocities. VLBI measurements within the United States over the past four years have established an upper bound on the internal stability of the North American Plate. These results show the internal deformation rate to be less than one centimeter per year. If this is confirmed by measurements on other plates, the important question of plate rigidity may be resolvable in the next few years.

The laser and VLBI systems also participated, from August through October 1980, in an international campaign for evaluation of methods for measurement of Earth rotation and polar motion. Project MERIT (Measurement of Earth Rotation and Intercomparison of Techniques), is sponsored by the International Astronomical Union and is intended to lead to a new system for Earth rotation monitoring in the late 1980's.

In **mid-1979**, measurements of the relative location of the JPL and the Goldstone deep space network station in Southern California over several months indicated an unusually large western movement (20cm) to the northwest (the sense of movement along the San Andreas Fault, which runs between JPL and Goldstone), followed by a return to the original location. Similar movement was detected in the same area by the USGS using conventional methods. This movement is considered anomalous and is not understood at present. Measurements were continued in 1980, but no further movement has been detected. In October 1980, a new system, the transportable laser ranging station, built for **NASA** by the University of Texas, was located at JPL to continue the measurements and to check on the results being obtained with the mobile VLBI system. Measurement strategy is being closely coordinated with the Earthquake Studies Office of USGS.

In 1981, mobile laser and VLBI systems will be located at approximately twenty sites in California, selected in coordination with the USGS, NOAA, and others, to begin the most intensive study of crustal deformation ever attempted. **Also** in 1981, measurements of plate motion and rotational dynamics will be continued.

The geodynamics research and technique development effort includes studies of solid Earth dynamics, crustal movement, gravity and magnetic field modeling and new system concepts. The objectives are to develop models and theoretical formulations which will lead to a better understanding of the physical processes involved and to provide improved methods for crustal deformation measurements, gravity field survey, and global time transfer. In FY 1981, studies of regional crustal modeling in selected areas, of the interior structure of the Earth, and the methods of modeling the Earth's gravity field will be conducted at universities and NASA Centers. Engineering prototypes of SERIES (Satellite Emission Radio Interferometric Earth Surveying), a system which will use signals from the global positioning system (GPS) for monitoring local crustal deformation (20-200km), will be tested to verify performance. Laboratory models of a single-axis cryogenic gravity gradiometer will be completed and tested.

CHANGES FROM FY 1981 ESTIMATE:

The reduction of \$1.4 million is due to a general reduction by Congress to the NASA appropriations request.

BASIS OF FY 1982 ESTIMATE:

In FY 1982, crustal deformation measurements in California will be continued and extended to include most of the western part of the United States. The plate motion, plate stability, polar motion, and Earth rotation measurements will be continued. Measurements of the relative motion of the Nazca and South American plates will be initiated. This motion is suspected to be as large as 18cm per year - the largest movement for any of the plates and consequently an ideal place to test tectonic theories. Cooperative agreements with other countries for joint studies of crustal movements in seismically active areas will be initiated on the basis of responses to the announcement of opportunity released in October, 1980. In addition, studies by 25 investigators selected to analyze laser ranging data for studies of polar motion, Earth rotation, plate motion and solid Earth tides will be completed in FY 1982.

Mobile lasers will be located within the United States, on Easter Island and Tahiti, and in Australia. Fixed lasers will be operated in the United States, South America, Australia, and perhaps India. These observations will be coordinated with laser systems operated by countries in Europe and by Japan. To support the regional crustal deformation studies, a second transportable laser ranging station will be completed, upgrade of two mobile VLBI systems and procurement of a third will also be completed, and three mobile lasers will be modified to improve ranging performance from 5cm to 1-2cm. Modeling studies of crustal movement and internal core dynamics will be continued. SERIES units will be upgraded for field use and data from these units will be intercompared with other GPS receiver concepts.

Geological Applications Program (GAP)

	1980	1981		1982
	<u>Actual</u>	Budget <u>Estimate</u>	Current <u>Estimate</u>	Budget <u>Estimate</u>
		(Thousands of Dollars)		
Geological applications program.....	---	---	---	10,000

OBJECTIVES AND STATUS:

The goal of the geological applications program (GAP) is to improve the effectiveness of global assessment, exploration, and development of mineral and energy resources through the use of space techniques. The objectives of the program are: (1) to develop remote sensing methods for systematic geologic mapping on a global basis, and (2) to develop improved geological models which employ space acquired data for resource evaluation and development. The program selectively identifies a series of remote sensing techniques with proven potential for geologic mapping and crustal research. The technical sophistication of these techniques will be upgraded through intensive research and development. At the same time, a series of test projects will be conducted at different spatial scales in different physical environments to evaluate experimentally the applicability of remote sensing methods to nonrenewable resource assessment and development. Practical analysis of specific test sites will be performed by investigator consortia involving representatives of Federal agencies, private industry, and academia. Consequently, geologic mapping techniques and mineralization models developed by the program will be readily integrated into current methods of resource evaluation and development.

GAP is responsive to national concerns about the availability and long-term supply of minerals, gas, and oil essential to the operation and growth of the United States economy, as recently expressed in the National Materials and Minerals Policy, Research, and Development Act of 1980. GAP is designed to determine the utility and optimize the development of space remote sensing methods with respect to national needs for global nonrenewable resources information. GAP will place the United States in a unique position in terms of exploiting satellite technology for global resource evaluation and national materials policy formulation in the late nineteen-eighties.

GAP is a time-phased program. The first phase, being proposed for initiation in FY 1982, is five years in duration. GAP plans have been developed through a series of meetings and workshops with private industry, other Federal agencies (notably the United States Geological Survey, Department of Energy, and the National Science Foundation), and academia.

BASIS OF FY 1982 ESTIMATE:

Funding provides for development and testing of remote sensing techniques for purposes of rock-type discrimination, geobotanical mapping, topographic analysis, and crustal modeling. Geological mapping test case studies will be conducted jointly with private industry in areas with different vegetative cover.

These studies will be conducted in areas of **known** mineralization. Specific test sites will be selected jointly with private sector companies. Candidate sites involve areas containing known deposits of chromium, uranium, titanium, and oil and gas. A mineralogenic study project will be initiated in the Caribbean region to model the distribution of mineral deposits in different tectonic environments. Large area mineral assessment experiments will begin in two distinctly different physical environments - Alaska and the southwestern United States. These projects will be conducted in cooperation with the Departments of the Interior and Energy, and relevant state agencies.

BASIS OF FY 1982 FUNDING REQUIREMENTS:

	<u>ENVIRONMENTAL</u>		<u>OBSERVATIONS</u>		Page No.
	<u>1980 Actual</u>	<u>1981 Budget Estimate</u>	<u>1981 Current Estimate</u>	<u>1982 Budget Estimate</u>	
		(Thousands of Dollars)			
Upper atmospheric research program.....	12,400	13,500	13,500	15,000	RD 7-34
Applied research and data analysis.....	48,570	49,900	48,100	56,500	RD 7-36
Shuttle/Spacelab payload development.....	9,600	1,700	1,700	5,800	RD 7-41
Operational satellite improvement program.....	7,400	9,200	9,200	13,800	RD 7-43
Earth radiation budget experiment.....	13,720	17,000	20,300	24,000	RD 7-44
Halogen occultation experiment.....	8,000	4,500	4,500	7,500	RD 7-46
Extended mission operations.....	5,800	8,000	8,000	11,400	RD 7-47
National oceanic satellite system (NOSS).....	---	5,800	5,800	34,600	RD 7-49
Nimbus-7	500	---	---	---	---
Upper atmospheric research satellite experiments and mission definition.....	---	---	---	20,000	RD 7-51
NOSS research.....	---	---	---	6,000	RD 7-53
Total.....	<u>105,990</u>	<u>109,600</u>	<u>111,100</u>	<u>194,600</u>	

OBJECTIVES AND STATUS:

The goal of NASA's environmental observation program is to provide a capability to measure and predict those key atmosphere and oceanic processes which affect our daily lives and longer term activities. In general terms, the methodology employed involves the identification, measurement, understanding, assessment, and prediction of these processes; development of the basis for the most suitable operational measurement systems; and transfer of these systems to the appropriate sector (Federal, state, local, private) together with the supporting technology necessary for their optimal use.

To achieve this goal a number of significant objectives have been set for the next decade. These include advancing the understanding of the upper atmosphere through the determination of the spatial and temporal distribution of ozone and select nitrogen, hydrogen, and chlorine species in the upper atmosphere, a dynamic description of verifying techniques for monitoring and predicting regional and global air pollution; the improvement of operational weather satellite capabilities; optimization of the use of space-derived measurements in weather forecasting; improvements in knowledge of severe storms and forecast capabilities; implementation of an operational ocean surface wind, temperature, and wave observing capability; a more thorough understanding of large-scale open ocean currents; and an improved knowledge of seasonal climate variability leading to the development of a long term strategy for climate observations and prediction.

Remote sensing from space is the principal method that NASA uses to accomplish its objectives. Application of remote sensing requires a balanced set of activities including: analytical modeling and simulation, laboratory research of fundamental processes, development of instrumentation, flight of the instruments on Shuttle and dedicated spacecraft, collection of in situ ancillary or validation data, validation of the remotely-sensed data, scientific analysis of data, and transfer of the capabilities to other agencies (Federal, state, local) or the private sector. The approach is to develop a technological capability and a strong scientific base and then to collect appropriate data (from space and in situ) which, taken together, will address a particular program objective.

Our studies of the upper atmosphere have made progress in determining the spatial and temporal distribution of ozone, determining the interaction among key processes and developing a strategy for observing the upper atmosphere. The potential threat of man's activities to the ozone layer is of continuing concern. The processing of Nimbus Backscatter Ultraviolet (BUV) total ozone and upper stratospheric ozone data for the period 1970-1977 has been completed and analysis of this important data base will continue. We have been able to separate annual from biennial trends and have derived ozone distributions as a function of geographic location and altitude. We have continued to study the necessary next step in obtaining the data base required to validate and advance our predictive capability in the upper atmosphere. This step would be the development of the upper atmospheric research satellites which would provide the capability to advance our understanding of the coupling mechanisms in this region.

A number of new instruments which are needed to achieve the objective of measuring the key chemical species in the upper atmosphere have been developed and tested. Work is continuing with the Environmental Protection Agency in observing regional air pollution episodes (possible precursors of acid rain) with Geostationary Operational Environmental Satellite (GOES) pictures. As part of our effort to understand pollution in the lower atmosphere and the role man's actions may have, we observed a greater than expected seasonal variation of atmospheric ammonia possibly due to the spring application of fertilizers. If so, man's activities may be a major source of this important tropospheric chemical and could affect the global budget of fixed nitrogen.

NASA is continuing to develop, with the National Oceanic and Atmospheric Administration (NOAA), unified national satellite capabilities for observing winds, temperature profiles, sea surface temperature, and other meteorological parameters on an operational basis. As part of our continuing support to NOAA, the NOAA-C satellite is being prepared for launch in May 1981 to replace TIROS-N. TIROS-N has exceeded its design life and along with NOAA-A has verified the utility of this new series of operational meteorological satellites.

Use of remote sensing to study the ocean is proceeding with the analysis of data from the Geodynamic Experimental Ocean Satellite (GEOS), the ocean dynamic satellite (Seasat), and the oceanographic and air pollution monitoring satellite (Nimbus). Seasat and Nimbus data have verified our ability to observe from space key features of the ocean such as surface winds, sea surface temperature, surface waves, characteristics of sea ices and ocean color. Based on this capability we are proceeding with NOAA and DOD in the development of the National Oceanic Satellite System (NOSS). In addition, our research activity will focus on the problem of determining the general circulation of the oceans through the use of satellites to measure ocean topography. A major emphasis will be on joint experiments with the academic community, the National Science Foundation, and other agencies to study the fundamental processes involved in and measured by remote sensing to further our understanding of ocean physics and observational techniques. In addition, the assimilation of remote data and the resulting impact on ocean and weather forecast models will be studied.

As part of the climate activity, we have progressed in the development of instruments for the Earth Radiation Budget Experiment (ERBE) which will fly in 1983 on NOAA-F and on the Earth Radiation Budget Satellite (ERBS), and in 1985 on NOAA-G. This schedule provides the overlap needed to extend the data base and permit an analysis of the diurnal variability of the earth radiation field. Instruments of similar design on Nimbus 6 and 7 have already measured global radiation patterns in a limited way. Evidence collected since 1976 from Nimbus, the Solar Maximum Mission and sounding rockets suggests that the "solar constant" is more variable both in magnitude and frequency, than previously believed.

In FY 1982, significant advances will be made in preparing for future satellite observations of both the atmosphere and the ocean. NOSS will move into a development phase with instrument, ground system and satellite detailed design. The instrument design and development, ground data handling facility design, and mission definition for the potential upper atmospheric research satellite missions will be initiated in time for a first launch in the fall of 1986.

Upper Atmospheric Research Program

	1980	1981		1982
	<u>Actual</u>	<u>Budget</u> <u>Estimate</u> (Thousands of Dollars)	<u>Current</u> <u>Estimate</u>	<u>Budget</u> <u>Estimate</u>
Research support.....	10,900	12,400	12,400	13,700
Upper atmospheric research balloon program.....	1,000	1,100	1,100	1,300
Spacelab payload definition.....	<u>500</u>	<u>---</u>	<u>---</u>	<u>---</u>
Total.....	<u>12,400</u>	<u>13,500</u>	<u>13,500</u>	<u>15,000</u>

OBJECTIVES AND STATUS:

The upper atmospheric research program was formulated in compliance with a Congressional mandate to NASA to develop and implement a comprehensive program of research, technology, and monitoring of the phenomena of the upper atmosphere. The resulting program is aimed at improving basic scientific understanding of the upper atmosphere and methods needed to maintain its chemical and physical integrity.

In particular, the goal of the program is the improved prediction of man's impact upon the ozone layer and the effects of changes in the upper atmosphere upon our environment. In order to accomplish this, efforts are underway: (1) to improve upper atmospheric models, validate them, and assess their uncertainties; (2) to measure minor chemical constituents, temperature, and radiation fields; (3) to develop sensors capable of remotely sensing all aspects of the upper atmosphere from space; (4) to assemble and maintain the existing long-term data base of stratospheric ozone measurements and long time-scale natural variations in order to detect man-made ozone changes; and (5) to carry out laboratory kinetics and spectroscopy studies to support these activities.

Recent laboratory kinetics studies have provided improved data for the photochemical models which are used to predict ozone depletion by chlorofluoromethanes and other compounds containing chlorine and bromine. These data have added additional insight on the role of bromine (important if the concentration in the upper atmosphere should increase), the role of temporary sinks, and the chemistry of the radical HO₂. Current models of the impact of continued release of chlorofluorocarbons 11 and 12 at the 1977 rate predict about 10 percent ozone depletion at steady state. However, this value would increase by about one-third if the releases of other man-made chlorine-containing compounds continue at present levels. Recent results from two-dimensional models on stratospheric ozone perturbation investigations serve to

elaborate on the seasonal and latitudinal variations in the ozone change. Several new instruments which will be useful in meeting our objectives related to the global climatology of ozone and key nitrogen, hydrogen and chlorine species in the upper atmosphere have been developed and tested. These include instruments developed for in situ and remote measurements of trace atmospheric constituents such as the high speed interferometer, the laser heterodyne radiometer, the brassboard version of the Halogen Occultation Experiment (HALOE), new resonance fluorescence instruments, and a high resolution far infrared emission spectrometer. An extensive workshop to assess the status of the ozone depletion problem is planned for April 1981.

The balloon support program provides for approximately 45 direct and remote atmospheric measurements in the altitude range up to about 45 kilometers.

BASIS FOR FY 1982 IMATE:

During FY 1982, NASA will continue the assessment and evaluation of man-made and natural perturbations of the stratospheric ozone layer. The development of models (one-, two- and three-dimensional) which couple radiative, dynamic, and chemical processes will continue; the confirmation of chemical mechanisms by simultaneous measurements of stratospheric trace species using multisensor platforms will be extended; improvements in the laboratory kinetics and spectroscopy data base will be sought; and new and improved techniques will be developed for detecting additional trace species and remotely measuring winds. There will be increased emphasis on the analysis of satellite data sets (Nimbus -6, -7 and Solar Mesospheric Explorer), and there will be a modest expansion of the research program into the mesosphere because knowledge of the coupling between the mesosphere and the stratosphere is necessary for understanding the complex interactions among radiation, chemistry, and dynamics in the upper atmosphere, and the relationship between solar variations and terrestrial weather and climate.

The balloon program will be continued at a level of approximately 45 flights per year and will provide key measurements of the photochemically active trace species important in the stratospheric ozone balance. These balloon flights provide the principal capability in our validation of the photochemistry program. Balloon flights also provide for instrument calibration and intercomparisons of different measurement techniques. Atmospheric dynamics studies using aircraft and super-pressure balloons as sensor platforms will be initiated. These platforms provide the best methods for studying stratospheric-tropospheric interchange and to determine how large air masses are exchanged between hemispheres. Studies for future instruments will continue progress toward developing spaceborne active and passive measurement capabilities to provide the global data on trace species, dynamic processes, and meteorological parameters needed in understanding the atmosphere.

Applied Research and Data Analysis (Environmental Observation)

	<u>1980</u> <u>Actual</u>	<u>1981</u> <u>Budget</u> <u>Estimate</u> (Thousands of Dollars)	<u>Current</u> <u>Estimate</u>	<u>1982</u> <u>Budget</u> <u>Estimate</u>
Applied research and data analysis in:				
Stratospheric air quality	3,980	5,000	4,800	6,200
Tropospheric air quality.....	4,260	4,600	4,400	5,900
Global weather (including GARP).....	10,340	11,100	10,500	13,100
Severe storms.....	5,100	5,400	5,200	7,400
Ocean processes.....	14,605	15,200	15,200	16,600
Climate.....	7,975	8,600	8,000	7,300
National oceanic satellite system (NOSS) action	<u>2,310</u>	<u>---</u>	<u>---</u>	<u>---</u>
Total.....	<u>48,570</u>	<u>49,900</u>	<u>48,100</u>	<u>56,500</u>

OBJECTIVES AND STATUS:

The applied research and data analysis (AR&DA) activities within the environmental observation program comprise a core of effort which is fundamental to the application of space technology to the Nation's pressing environmental concerns. Atmospheric programs include global weather, severe storms and local weather, and stratospheric and tropospheric air quality. Ocean processes research includes general oceanic circulation, air-sea interactions, coastal water studies, sea and glacier ice studies and marine boundary layer studies. A climate program enables special formulation and study of space-derived data that will interrelate the physics, dynamics, chemistry and radiation balance of the atmosphere and the oceans in order to understand basic climate sensitivities and to study the requirements for a space monitoring system.

AR&DA program objectives are to study tropospheric and stratospheric chemical composition and pollution; to model the radiative budget of our planet; to improve numerical weather prediction; to determine the morphology of lightning and severe storm occurrence; and to develop and demonstrate a capability for remotely sensing near-surface properties of the ocean and to relate these properties to characteristics in both the atmosphere above and ocean below the air-sea

interface. To study climate, NASA takes a long-term perspective of the phenomena of the atmosphere and oceans with the objective of defining the data requirements, and interpreting the global data set obtained from spaceborne platforms. Such data are vital to the development of a long-term predictive capability. Each element of the program supports the development and demonstration of remote sensing technology; the development of algorithms to extract geophysical parameters from remotely acquired data; suborbital and ground-based experiments to measure fundamental properties and processes of the environment and provide a base for remote sensor development; fundamental research into the processes at work in the environment; and the development of models which express the current understanding of all or part of this system and provide a predictive capability for key environmental parameters.

AR&DA activities consist of a comprehensive, integrated program of research, technology, development, environmental measurement and interpretation, user-oriented cooperative demonstration projects, and technology transfer. In the AR&DA program, concepts are developed for advanced sensors and instruments for demonstration; advanced studies are conducted for the definition of new systems and missions; and support is provided for the transfer of new technology to the user community.

Our studies in stratospheric air quality emphasize accurate measurements and comprehensive ozone analyses. An international rocketsonde intercomparison of several different sensors measuring ozone has been successfully completed recently. Several sensors from the United States, India, Canada and Australia have been compared to establish their accuracy and precision in order to provide "ground truth" testing of the satellite systems. Analysis of the intercomparison will be extended. The Nimbus-4 Backscatter Ultraviolet (BUV) data, collected during its lifetime (1970-1977), is being analyzed and made available to the scientific community as an initial satellite data base for global ozone climatology to complement the ground Dobson network data base. Further satellite data from the solar mesospheric explorer (SME), from the Nimbus-7 Scanning Backscatter Ultraviolet and Total Ozone Monitoring Spectrometer (SBUV/TOMS), and from the Nimbus-7 Limb Infrared Monitor of the Stratosphere (LIMS) experiment are being collected, processed, and interpreted. The understanding of ozone processes will continue to be improved by various field studies to better understand field species in the catalytic cycles that destroy ozone and by the development of a hierarchy of models to explain the chemical, dynamical and radiative processes of the stratosphere.

Other activities with the Environmental Protection Agency are continuing as we pursue the application of existing and future systems to pollution in the lower atmosphere. One promising technique is the use of the Geostationary Operational Environmental Satellites (GOES) to observe and track polluted air masses. We are already observing regional air pollution episodes (the precursors of acid rain) with GOES pictures.

Over the twenty years since the launch of the first weather satellite, NASA has continued the development, with the National Oceanic and Atmospheric Administration (NOAA), of an increasingly sophisticated complement of satellite capabilities for the measurement of winds, temperature profiles, sea surface temperature, and other meteorological parameters on a routine operational basis. Hurricanes and storm cells are routinely tracked by images from the GOES

satellites, and improved forecasts are using the operational temperature soundings. More recently in a joint effort with NOAA, a pilot centralized storm information system has been established in Kansas City which will receive weather satellite data far more speedily and improve short-term forecasts. The observational phase of the Global Weather Experiment (GWE) has been successfully completed, the analysis of data has begun, and the first results are now available. Two independent analyses of the GWE data confirm the power of satellite observations in numerical forecasting. This year we initiated the purchase of an advanced vector processor to enhance capabilities to assess the GWE data and to provide improved model forecasts in the weather, climate and upper atmosphere programs. Laboratory studies and model improvements continue in several areas such as thunderstorm prediction. New instruments are already under development with NASA support to further improve operational weather satellite capabilities.

We have completed the groundwork required to implement a number of activities to meet objectives for oceanic operational observations and determination of ocean circulation. Seasat data has demonstrated that scatterometer observations enable space mapping of the detailed structure of the ocean surface wind fields, including atmospheric fronts and typhoons. Altimeter observations enable mapping of surface waves and circulation features such as the Gulf Stream and mesoscale eddies. Microwave radiometer observations enable mapping of the characteristics of sea ice. Color scanner observations enable mapping of chlorophyll concentration. Taken collectively, these observations will help enable the determination of the general circulation of the oceans--both the wind-driven and geostrophic components--along with sea ice coverage and primary biological productivity in the oceans.

CHANGES FROM FY 1981 BUDGET ESTIMATE:

The reduction of \$1.8 million in FY 1981 results from an overall Congressional reduction in the NASA appropriation request.

BASIS OF FY 1982 ESTIMATE:

In FY 1982, research, technology and data analysis will be performed in the areas of stratospheric and tropospheric air quality, global weather, severe storms, and oceanic and climate processes, especially where they result in assessments and improve short and medium range weather forecasts. Laboratory, field, and advanced studies will address our specific objectives which are to: (1) obtain global climatology of ozone and key nitrogen, hydrogen, and chlorine species in the upper atmosphere; (2) develop a longer-term monitoring strategy for the upper atmosphere; (3) operationally characterize the dynamics of regional air pollution episodes; (4) improve operational weather satellite capabilities; (5) increase forecast usefulness of space derived meteorology; (6) significantly improve our understanding of severe storms; (7) improve our storm forecasting capability; and (8) support the National Climate Program (PL 95-367) through studies related to the Earth radiation budget climate model developments and special studies.

In N 1982, the stratospheric air quality program will continue to focus on ozone perturbations. Key modeling and analysis efforts and advanced instrument and technique development for field and laboratory studies will be maintained. Preparations for the flights of HALOE, ATMOS, and other advanced sensors will continue so as to provide essential observations of the complex chemistry of chlorine. System studies and instrument developments continue for the Upper Atmospheric Research Satellite Experiments (UARSE) activity. This group of instruments will provide a critical global data set for studying the interaction among chemistry, radiation and dynamics of the upper atmosphere. Research utilizing data to be obtained from the Shuttle Atmospheric Trace Molecules by Spectroscopy (ATMOS) instrument will provide essential baseline Observations from which future atmospheric modifications can be measured.

For the tropospheric air quality program, the FY 1982 activities will include development of numerical pollution models, comparisons of regional model predictions with remote sensing results, studies of key reaction rates, and development of active and passive remote sensors (including variable wavelength lidar systems). This funding will permit participation in the joint NASA/EPA studies of pollution episodes and development of aircraft instrumentation for joint NASA/NSF global atmospheric measurements. Through activities in this program, we will be able to test regional air pollution models through data gathered in 1982 field programs, define advanced microwave sensors for temperature, pressure, and moisture plus a laser instrument for the measurement of trace constituents from space, and develop improved temperature, moisture, and trace constituents retrieval algorithms.

The activities related to weather and storms will support measured progress toward improved operational observing systems, additional uses of existing systems and orderly transfer of those capabilities to operational settings. In the global weather program, development and demonstration of temperature, moisture, and pressure sounders will be maintained. GWE data sets will be processed and analyzed, the data used in the model experiments to assess the impact of satellite data on forecast models, and to increase our understanding of atmospheric phenomena. The research program on zero-G experiments will provide information on the physical processes occurring in macroscale atmospheric dynamics which cannot be achieved by any other means. These funds will continue early sensor development, and permit the proof of concept inherent to these instruments as well as provide basic data on the dynamics of the atmosphere and oceans.

The FY 1982 activities in the severe storms and local weather research program will allow us to pursue techniques to improve our understanding of and, ultimately, our ability to forecast severe weather events. Assimilation techniques for high resolution observations will be tested while new severe storm indicators such as lightning will be studied. Progress can be expected in doppler lidar techniques for the remote measurement of winds. Assessment of the vertical soundings of temperature and moisture from GOES-4 should provide an evaluation of the validity of the data, as well as an indication of its utility in severe weather forecasting. Other severe storm research will include efforts to improve the basic understanding of storm development and the specific conditions which initiate storms, tornadoes, and damaging downdrafts, and produce destructive cloud-to-ground lightning. Efforts in the numerical modeling of storms and their environments will be supported in order to enhance capabilities in computerized forecasting. The severe storms and local weather research program will include software development and operation support for the joint NASA/NOAA

Centralized Storm Information System (CSIS) program in Kansas City, data analysis and modeling for forecasting improvement of tropical cyclones, severe local storms and tornadoes; man-computer interactive data system technique development; storm severity indicator studies; and aircraft doppler lidar field experiments.

An advanced vector processor, to be delivered in FY 1982, will greatly improve our presently overtaxed computing capacity. This computer will enable us to handle and assimilate satellite data more rapidly to initiate and run more realistic numerical weather prediction models as well as support other environmental observation programs including climate sensitivity studies and ocean models.

In FY 1982 our oceans research program will include processing Seasat data records into final geophysical units and their subsequent analysis; evaluation of the performance of X/L/C-band aircraft Synthetic Aperture Radar (SAR) in conjunction with the NSF warm Gulf Stream rings and coastal ocean dynamics experiments; characterization of sea ice properties by various remote sensing techniques; definition of altimetry dependence on sea state; investigation of photoplankton productivity associated with physical and chemical ocean properties near the Nantucket Shoals in cooperation with the National Marine Fisheries Service; refinement of techniques for assimilation of wind data from the scatterometer into numerical models; and development of a shipborne lidar system for basic studies of optical oceanography. The ocean processes program will develop techniques for assimilation of satellite data--especially scatterometer wind data--into numerical models, and demonstrate a remote sensing system which will supply specific global oceanographic data on a routine and repetitive basis to meet specific user needs.

The NASA climate research program, operating within the context of the national climate program, will conduct climate parameter sensitivity studies to help establish the requirements for global climate observations, will provide global data sets of satellite-acquired climate measurements (initial emphasis on radiation budget parameters), and will utilize climate models in order to help define space observing systems. Specific near-term efforts will include quantitative studies of the effects of clouds and aerosols on climate variations.

The augmented data processing capabilities at NASA's Goddard Space Flight Center will be utilized for improving numerical climate models, incorporating the results of current theoretical and experimental studies of climate processes, in order to simulate the seasonal cycle and interannual variability of climate. A number of university scientists have been selected to participate in collaborative studies with NASA scientists aimed at improving the models needed for these studies.

Shuttle/Spacelab Payload Development (Environmental Observation)

	1980	<u>1981</u>		1982
	<u>Actual</u>	<u>Budget</u> <u>Estimate</u>	<u>Current</u> <u>Estimate</u>	<u>Budget</u> <u>Estimate</u>
		(Thousands of Dollars)		
Measurement of air pollution from satellites (MAPS).....	450	100	100	100
Atmospheric trace molecules observed by spectroscopy (ATMOS).....	4,700	600	600	2,100
Atmospheric cloud physics laboratory (ACL).....	3,030	700	700	---
Principal investigator instrument development and reflight program.....	<u>1,420</u>	<u>300</u>	<u>300</u>	<u>3,600</u>
Total.....	<u>9,600</u>	<u>1,700</u>	<u>1,700</u>	<u>5,800</u>

OBJECTIVES AND STATUS

The space transportation system offers the opportunity for frequent, short-duration flights for instruments and associated experiments. The environmental observation program has incorporated this new capability in the Spacelab payload development activities in these important aspects: (1) early tests, checkout and design refinement of remote sensing instruments whose ultimate use will be in long duration free-flying missions; (2) short-term data gathering of atmospheric and environmental information for basic research and analysis where long-term observations are not necessary or are impractical; (3) research into processes which cannot be accomplished effectively in ground-based laboratories.

The Measurement of Air Pollution from Satellites (MAPS) experiment is a gas filter correlation radiometer designed to measure the levels of tropospheric carbon monoxide and the extent of interhemispheric mass transport in the lower atmosphere. The instrument has been delivered to KSC and integrated into the OSTA-1 pallet. Launch is scheduled on orbital flight test mission-2 (OFT-2).

The objective of the Atmospheric Trace Molecules Observed by Spectroscopy (ATMOS) experiment is to make detailed measurements of gaseous constituents (e.g., hydrogen chloride, water, ammonia, methane) in the Earth's atmosphere using the techniques of infrared absorption spectroscopy. The data will allow the determination of the compositional structure of the upper atmosphere, including the ozone layer and its spatial variability on a global scale. The

instrument delivery is scheduled for December 1981 with a planned launch in 1984. The instrument design has been completed and the development and qualification phase has begun.

In response to an announcement of opportunity, a number of principal investigator class instruments were selected for definition, development, and reflight as part of the Spacelab payloads programs. The experiments selected include reflights of some instruments under development in other NASA offices for flight on the orbital flight test series, Spacelab-1, and Spacelab-2. These experiments are: (1) an active cavity radiometer for solar irradiance measurements; (2) a solar ultraviolet spectral irradiance monitor; (3) an imaging spectrometric observatory for trace constituent measurements; and (4) a photometric imager for lightning research. Several foreign investigations which are complementary to NASA programs have been selected; funding is provided by the foreign agency sponsoring the investigator. The reflights and new principal investigator instruments will continue the research activities in atmospheric chemistry, solar intensity and variability, and upper atmospheric winds. In addition, studies will be performed on the optimal utilization of Synthetic Aperture Radar (SAR) for observing ocean and sea ice conditions. Flight plans have been delayed one year due to the FY 1981 budget constraints.

BASIS OF FY 1982 ESTIMATE:

Measurement of Air Pollution from Satellites (MAPS) - - FY 1982 funds will be used to support the science team activities, improved algorithm development, and data reduction.

Atmospheric Trace Molecules Observed by Spectroscopy (ATMOS) - - the instrument is scheduled for delivery to JPL in December 1981. After delivery of the instrument, a verification and familiarization program will be conducted by the experiment team to establish baseline characteristics of the instrument. Delivery of the instrument for Shuttle integration is expected to be early 1984 with the initial flight in 1984.

The Principal Investigator Instrument Development/Reflight Program - - The FY 1982 funds will allow the continuation of definition studies for the solar and terrestrial atmospheric spectrometer and the atmospheric general circulation experiment; development of the active cavity radiometer II; and reflight of the nighttime and daytime orbital survey of lightning and the geophysical fluid flow cell. In addition, feasibility studies will be conducted on facility class instruments for Light Intensification Detection and Ranging (LIDAR), Cryogenic Limb Scanning Interferometer and Radiometer (CLIR), and Atmospheric Microwave Temperature Sounder (AMTS).

The FY 1982 funds will also be used to: (1) support the flights of Shuttle Imaging Radar for oceanic and ice applications; (2) study modifications to a Seasat-class altimeter so that it can be flown on the Shuttle and scanned in the cross-track mode, and (3) define the feasibility of adapting the Seasat-class scatterometer so that it can be flown on the Shuttle and used in the dual-frequency mode for measuring directional spectra of surface waves.

Operational Satellite Improvement Program (OSIP)

	1980	1981		1982
	<u>Actual</u>	Budget <u>Estimate</u>	Current <u>Estimate</u>	Budget <u>Estimate</u>
		(Thousands of Dollars)		
Research and development for improvement for operational satellite systems.....	7,400	9,200	9,200	13,800

OBJECTIVES AND STATUS:

The objectives of the operational satellite improvement program are to: (1) carry out the research and development activities which will provide advanced sensors, spacecraft subsystems, and ground equipment for the operational meteorological satellites; and (2) perform definition studies for incorporation of user-dictated changes which affect the total system configuration and capabilities. Current development activities include the following: (1) modifications to the advanced TIROS-N spacecraft to permit launching from either the Shuttle or an expendable launch vehicle; (2) continued operation of the Visible/Infared Spin Scan Radiometer (VISSR) Atmospheric Sounder (VAS) aboard GOES-4; (3) development of the Solar Backscatter Ultraviolet (SBUV) instruments for monitoring of ozone fluctuations in the upper atmosphere and for calibration flights aboard the Shuttle; (4) future operational characteristics studies; and, (5) modification and improvement of direct readout equipment for operational use.

The results from the GOES-4 VAS demonstration experiment have been very encouraging. The data is presently being used for research purposes at the University of Wisconsin and the Goddard Space Flight Center. This data can be acquired continuously until the spacecraft is required to fulfill its operational mission. The SBUV contract was signed in December 1980 and development is now in process.

BASIS OF FY 1982 ESTIMATE

The FY 1982 funds will provide for continuation of the following major tasks: (1) modification of the TIROS spacecraft to be compatible with the-Shuttle and an expendable launch vehicle; (2) development of the SBUV instrument to be flown on the polar-orbiting spacecraft and the SBUV calibration unit for underflight on the Shuttle (the calibration unit is being developed under a joint NASA/SBA program); and (3) VAS demonstration, experiment operation, validation and assessment. Two activites that will begin in FY 1982 are an advanced microwave sounding unit (AMSU) and a defintion study of the required characteristics of the geostationary spacecraft in the post-1990 time-frame. The objective of the new instrument is to provide more accurate temperature and moisture profiles from the polar orbiting spacecraft. The definition study will focus on the anticipated requirements that will cause significant departure from the spacecraft configuration in operation today.

Earth Radiation Budget Experiment

		1980	1981		1982
		<u>Actual</u>	<u>Budget Estimate</u>	<u>Current Estimate</u>	<u>Budget Estimate</u>
			(Thousands of Dollars)		
Spacecraft.....	■■				

OBJECTIVES AND STATUS:

More solar energy is absorbed by some regions of the Earth than by others. At the same time, more thermal energy is radiated into space by some regions than others. This differential heating is thought to be the driving force that sets the atmospheric winds and ocean currents into motion so as to transfer heat from warmer areas to cooler areas. The excess in the amount of solar energy absorbed over the thermal energy radiated to space continually changes for any given region, depending on the time of year, degree of cloudiness, snow and ice cover, atmospheric dust and aerosols, and properties and conditions of the surface.

The objective of the Earth Radiation Budget Experiment is to measure the temporal and spatial variations in the radiation balance over the globe. General agreement exists within the scientific community that the Earth's radiation budget must be monitored from space if we are to gain basic insights as to reasons for climatic fluctuations.

Experimental Earth radiation budget instruments have flown on the Nimbus satellites, and sampling studies based on those experiments have shown that adequate global coverage requires a multiple satellite system. They also indicate the need for improved calibration of the sensors. The NOAA satellites of the Tiros-N series will be flown in sun-synchronous orbits equipped with identical Earth radiation budget instruments in addition to the NOAA instrument complement. One of the NOAA satellites will have a morning equatorial passage time, while the other will have a mid-afternoon passage time. Adequate mid-latitude and equatorial coverage requires an additional satellite. Therefore, a third set of instruments will be flown on a NASA dedicated spacecraft in a 46° inclined orbit plane. Each equatorial region must be viewed at least once each month at each hour of the day, and the orbit altitudes and instrument view angles must be known to permit geographic location of the radiometer footprints. Together, the three satellites will provide accurate measurements of the monthly average radiation balance with regional, zonal, and global resolutions. The planned launch dates are 1983 and 1985 for the NOAA satellites and 1984 for the NASA ERBE satellite.

The scientific objectives and measurement requirements were developed by a combined NOAA/NASA/university/industry team of scientists. These requirements have been reviewed by a committee of the National Academy of Sciences. The ERBE instrument contract was awarded to TRW late in the 4th quarter of 1979, and development has proceeded satisfactorily. Both the conceptual and preliminary design reviews were completed in FY 1980. The start of the ERBE engineering model evaluation testing is planned for the third quarter of FY 1981, followed by the critical design review in the fourth quarter of FY 1981. Delivery of the ERBE instruments for NOAA-F is planned for the 4th quarter of FY 1982. Modifications to accommodate the ERBE instruments on NOAA-F are complete, and integrated spacecraft bus testing will be completed in FY 1983.

The contract for the SAGE II instrument which provides the aerosol measurements for the Earth Radiation Budget Experiment was awarded to Ball Aerospace Systems Division at the end of FY 1980 and engineering design is proceeding satisfactorily. The competitive selection process for the NASA dedicated spacecraft bus, Earth Radiation Budget Satellite (ERBS), has been completed and a contract award to the Ball Aerospace Systems Division is expected to occur in the second quarter of FY 1981. Four meetings of the ERBE science team have been conducted and the initial data processing algorithms have been completed. The directional model algorithms are currently being updated to include the latest earth radiation budget data from Nimbus and will be completed in the fourth quarter of FY 1981.

CHANGES FROM FY 1981 BUDGET ESTIMATE:

The FY 1981 budget estimate for this project has been increased by \$3.3 million to restore the FY 1980 funds which were reallocated to Landsat-D in FY 1980. This change in funding was made possible because the TIROS-N and NOM-6 satellites have exceeded their expected lifetimes and the planned launch dates for the follow-on NOAA satellites have been delayed. This in turn delays the launch readiness requirement for the NASA ERBS spacecraft because of the program requirement for simultaneous measurements by the ERBE-instrument-equipped NOAA spacecraft and the NASA spacecraft.

Within the project a reduction of \$2.4 million was permitted in the estimate for sensors because SAGE II, which is part of the instrument set for the ERBS, was delayed to be consistent with the revised ERBS schedule, and fewer technical difficulties with the ERBE instrument were encountered than had been anticipated. The \$4.08 million increase for the spacecraft reflects a greater than previously expected cost for the spacecraft; and the \$1.6 million increase in mission operations covers additional algorithm development, analysis for control center planning, and further review of spacecraft to space transportation system interfaces.

BASIS OF FY 1982 ESTIMATE:

FY 1982 funding will be used to complete the testing and deliver the first two flight model ERBE instruments, to initiate the integration of the first flight instrument on NOAA-F, to continue the assembly and testing of the remaining flight and calibration instruments so they can be delivered in FY 1983, to continue the testing of the data processing software, to complete the delivery of the SAGE II instrument and to continue the development of the ERBS spacecraft which will be completed in FY 1983.

Halogen Occultation Experiment

		1980	1981		1982
		<u>Actual</u>	<u>Budget</u> <u>Estimate</u>	<u>Current</u> <u>Estimate</u>	<u>Budget</u> <u>Estimate</u>
			(Thousands of Dollars)		
Sensor development.....	.....	8,000	4,500	4,500	7,500

OBJECTIVES AND STATUS:

The Halogen Occultation Experiment (HALOE) will provide global stratospheric vertical concentration profiles of key chemical species involved in the catalytic destruction of ozone due to chlorine compounds. These measurements will assist in estimating the depletion of stratospheric ozone due to natural and man-made causes involving chlorofluoro-methanes (CFM's). Specific objectives of HALOE are: (1) to monitor globally the vertical profiles of concentrations of stratospheric hydrogen chloride, hydrogen flouride, water and other trace gases of importance to the chlorine chemistry; and (2) to use the measured data (a) in obtaining horizontal and vertical maps of gas concentrations; (b) to perform a chlorine source analysis; (c) to validate chemical and dynamic models describing the effects of CFM's on the ozone layer; and (d) to aid in assessing the ozone depletion rate due to chlorine build-up in the stratosphere. A mission of one to two years will take place on the Earth radiation budget experiment (ERBE) mission scheduled for launch in 1984. The preliminary design review was held in January 1980, and the critical design review will be conducted in March 1981. The science team was selected through an announcement of opportunity and is now holding meetings. A single brassboard HALOE instrument has been fabricated and flown on an aircraft in 1980; results have been good. The HALOE instrument has been removed from Spacelab-3 due to increased costs associated with additional technical requirements for both Spacelab-3 and the ERBE free-flyer mission. HALOE's mission objective will not be substantially affected even though direct intercomparison of data and algorithms with atmospheric trace molecule spectroscopy will not be accomplished from the same platform.

BASIS OF FY 1982 ESTIMATE:

The FY 1982 funds will be used to continue fabrication and qualification of the engineering and flight units. The engineering unit is scheduled for delivery in March 1983 followed by the flight unit in August 1983. Science activities will focus on modeling techniques, data processing and formats, and the data validation plan.

Extended Mission Operations (Environmental Observations)

	1980	1981		1982
	<u>Actual</u>	<u>Budget Estimate</u>	<u>Current Estimate</u>	<u>Budget Estimate</u>
		(Thousands of Dollars)		
Operations for the Extended Mission of:				
Nimbus-5, -6, and 7.....	5,200	7,500	7,500	8,400
Stratospheric aerosol and gas experiment (SAGE).....	600	500	500	1,000
Solar mesosphere explorer (SME).....	<u>---</u>	<u>---</u>	<u>---</u>	<u>2,000</u>
Total.....	<u>5,800</u>	<u>8,000</u>	<u>8,000</u>	<u>11,400</u>

OBJECTIVES AND STATUS:

Since the launching of Nimbus-5, -6, and -7 in 1972, 1975, and 1978, respectively, significant quantities of global data on sea ice coverage, atmospheric dynamics and chemistry, the Earth's radiation budget, ocean temperature and ocean color have been gathered. Preliminary evaluation of the results has demonstrated the utility of the measurements, and the instrument techniques are starting to be used on operational satellites. Although the utility of the techniques may have been demonstrated, reduction and validation of these valuable data are continuing, as is the operation of the satellites themselves. There is a strong demand for historical, current, and future data regarding global precipitation, soil moisture, snow and ice cover, the Earth's radiation budget, atmospheric dynamics, and trace constituent concentrations and distribution. All contribute toward global weather trend studies, severe storm analysis and prediction, improved numerical forecast models and ozone concentration trend analysis.

An important contributor to the ozone and aerosol data base is the stratospheric aerosol and gas experiment (SAGE) satellite launched in early 1979. The measurements by this satellite of the stratospheric aerosol loading from the recent Mt. Saint Helens volcano eruptions are expected to contribute significantly toward our overall understanding of this natural perturbation to the stratosphere and its potential effect on weather and climate.

In September 1981 the Solar Mesosphere Explorer (SME) will be launched and will start to provide major inputs into our overall atmospheric parameter data base. SME will begin making some of the simultaneous measurements needed to start to understand the complex chemical processes taking place in the stratosphere and mesosphere.

BASIS OF FY 1982 ESTIMATE:

FY 1982 funding will support the operation, as well as the production and distribution of data from Nimbus and SAGE SME satellites. A ground truth program for verification of SME data is being initiated. These satellites will continue to produce an extremely valuable set of atmospheric and ocean observations during this time period. These observations provide a continued global data set on ozone concentrations which are important to determine natural variations and long-term trends, sea surface temperatures for real-time operational uses, extended earth radiation budget and aerosol measurements to enhance the interpretation from the upcoming ERBE mission, and coastal zone color measurements which will be used to better predict ocean productivity. The necessary correlative ground truth activity will also be supported. These in situ observations are essential to continue to verify the quality of the observations.

National Oceanic Satellite System (NOSS)

	1980	1981		1982
	<u>Actual</u>	<u>Budget</u> <u>Estimate</u>	<u>Current</u> <u>Estimate</u>	<u>Budget</u> <u>Estimate</u>
		(Thousands of Dollars)		
Spacecraft.....	---	2,000	2,000	13,900
Instrument development.....	---	3,200	3,200	12,000
Supporting activities.....	---	<u>600</u>	<u>600</u>	<u>8,700</u>
Total.....	---	<u>5,800</u>	<u>5,800</u>	<u>34,600</u>

OBJECTIVES AND STATUS:

The National Oceanic Satellite System (NOSS) is an interagency project to demonstrate the capability of remote sensing of the oceans from space and the data processing and distribution necessary to meet the operational informational needs of both the military and civil sectors--needs which range from operation of the Fleet to petrochemical exploration to management of marine resources. NOSS will also provide space observations of ocean conditions which are needed to extend the national capability to predict oceanic phenomena and to assess their interaction with human activities.

Both the Department of Defense and the Department of Commerce require timely, accurate oceanic information on a global scale. The United States Navy has expressed the need for NOSS data for the selection of operating areas, damage avoidance, ship routings, strategic submarine operations, logistic resupply, antisubmarine warfare acoustic predictions, and tactical ship routings. The National Oceanic and Atmospheric Administration (NOAA) has expressed the need for the same information to support such diverse activities as: (1) management and conservation of marine resources; (2) the prediction of weather; (3) the protection of life and property; (4) the preservation, conservation and development of the Nation's coastal resources; and (5) the provision of maps, charts, surveys, and specialized data for safe navigation. The NOSS data will be especially important in NOAA weather forecasting models. Provision of global ocean conditions data on a timely basis will improve the efficiency, safety, and cost of ship operations, transportation, off-shore oil and gas exploration and drilling platform operations, marine construction, commercial fishing, pollution monitoring, ice monitoring, and marine search and rescue.

The NOSS capability for remotely sensing the world's oceans and providing useful data to the user community in near real-time is not available by any other means. The vast majority of the world's oceans lie outside commonly traveled sea lanes and, thus, are unobserved by conventional methods. The capability of existing and planned meteorological satellites to measure characteristics of the oceans is severely limited. The collection of global and synoptic oceanic

data by the deployment of more conventional techniques (e.g., ships and buoys) would require thousands of individual remote platforms. Such a technique would be prohibitive both logistically and monetarily.

The oceanic features to be observed by NOSS include directional wind stress, sea surface topography, ice cap profiles, significant wave height, directional wave spectrum, sea ice patterns, internal waves, icebergs, sea surface temperature, wind speed, clouds, rain, and chlorophyll. The suite of sensors required for these observations include the scatterometer (SCAT), coastal zone color (CZCS), the large antenna microwave radiometer (LAMMR), and the altimeter (ALT). NOSS will be designed to produce data products describing these features with typically no more than a three to twelve hour delay from acquisition of the data by the spacecraft. This will demonstrate the characteristics of the data system that user agencies would require in a fully operational system. Mission lifetime will be sufficient to allow user agencies to evaluate fully the data's utility in the operational environment.

NOSS is planned to be a complete end-to-end oceanic monitoring system utilizing both microwave and optical oceanographic sensors, with a dedicated ground control, data processing, and distribution system. The initial NOSS spacecraft will be launched using the Space Shuttle in 1986.

NOSS is a jointly defined and funded program. NASA has overall program management responsibility. NOAA and DOD are responsible for defining system requirements, data products and formats. NOAA and DOD will also operate the NOSS during the five-year demonstration period which follows launch of the first NOSS spacecraft.

NASA and DOD will share the cost of developing and launching the initial spacecraft and NOAA and DOD will share the cost of subsequent launches and spacecraft; DOD and NOAA will also share the cost of the data processing and distribution systems' development and the five years of operations. Overall program policy and guidance for the NOSS program is provided by a tri-agency NOSS Steering Committee composed of one senior representative from each of the three agencies. Steering committee directives and decisions are converted into implementation guidelines by a tri-agency program management team and, ultimately, into hardware and software by the tri-agency NOSS Project Team located at GSFC.

The alternate systems concepts studies for NOSS were begun in August 1980 and will be completed by May 1981. NOSS system development and operations phase proposals will be evaluated during the latter part of FY 1981, followed by a contract in early N 1982.

BASIS OF FY 1982 ESTIMATE:

The FY 1982 estimate will support the initial funding of the NOSS development and for procurement of the spacecraft sensors. Specific activities during N 1982 involve initiation of the design of the spacecraft bus, the primary processing facilities, and the spacecraft sensors. Breadboard hardware circuits and subsystems for the spacecraft sensors will be fabricated and detailed engineering testing begun. In addition, geophysical algorithm development for near-real-time conversion of the remotely-sensed data into readily useable data expressed in engineering units, which began in 1981, will be continued throughout N 1982 in order to support timely specification, design and development of the NOSS ground data processing system.

Upper Atmosphere Research Satellite Experiments (UARSE)

	<u>1980</u> <u>Actual</u>	<u>1981</u> <u>Budget</u> <u>Estimate</u> (Thousands of Dollars)	<u>Current</u> <u>Estimate</u>	<u>1982</u> <u>Budget</u> <u>Estimate</u>
Upper atmosphere research satellite experiments and mission definition.....	---	---	---	20,000

OBJECTIVE AND STATUS:

An Upper Atmosphere Research Satellite (UARS) mission is the next logical step in NASA's congressionally mandated program to develop and implement a comprehensive program of research, technology development and monitoring of the upper atmosphere aimed at improving basic scientific understanding. UARS is planned to provide the first integrated measurements of ozone concentration, concentrations of chemical species that affect ozone, energy inputs, temperature, and winds in the stratosphere and mesosphere. It will extend the measurements of ozone, and of atmospheric parameters affecting ozone, that have been or will have been made by 1986 on Nimbus, SAGE, and HALOE and goes beyond them to measure key members of all important chemical families (hydrogen, nitrogen, chlorine, etc.) in the upper atmosphere simultaneously with dynamic parameters and solar energy input. UARS is a critical element in NASA's stratospheric research and monitoring strategy. It will provide the first full data set on stratospheric composition and dynamics that will be needed when very difficult regulatory decisions must be made on future production of chlorofluorocarbons. It will contribute to the assessment of the impact of stratospheric changes on climate and will provide data for a fuller understanding of the stratosphere essential for design and implementation of a long term stratospheric monitoring strategy.

On the basis of stratospheric measurement requirements, a tentative selection of UARS experiments has been made. These experiments draw heavily upon the experience derived from earlier satellites and satellite experiments (e.g. Limb Infrared Monitoring of the Stratosphere on Nimbus, and HALOE on ERBS). The experiments package includes infrared and microwave limb sounders requiring advances in cryogenics and microwave antennas beyond the earlier capabilities. Final design and development of the instruments for the UARS must be initiated early in FY 1982 to support the launch of the first UARS in 1986. A launch then will provide data coverage of the minimum and ascending phases of the solar cycle to complement other data (although more limited) obtained at the maximum and descending phases. It will avoid a data gap in our satellite ozone measurements that are accompanied by other species measurements. An advanced, interactive ground data handling facility design will also be studied as part of the UARSE activity. This system will provide for early reduction of the UARS data and their wide dissemination among the UARS experimenters and upper atmospheric theorists and modelers.

BASIS OF FY 1982 ESTIMATE:

FY 1982 funds will be used to initiate design and development of the instruments selected for flight from among those experiments that have been tentatively accepted, for mission definition, and to define requirements for the advanced ground data handling facility that will be implemented in the UARS program. The instruments are the longest lead time elements of the UARS program. Although there is considerable technological heritage for these instruments, their construction and testing in time for a 1986 launch requires initiation in FY 1982.

The ground data handling facility will involve a higher level of interaction among experimenters, and between experimenters and theoreticians than have past programs. Implementation of this concept requires that it be designed early in the UARSE effort so that individual experiments' data processing subsystems, including algorithms, can be designed for maximum interaction and effectiveness. Funding for a study of the ground data handling facility is included within the UARSE estimate.

National Oceanic Satellite System Research

	<u>1980</u> <u>Actual</u>	<u>1981</u>		<u>1982</u> <u>Budget</u> <u>Estimate</u>
		<u>Budget</u> <u>Estimate</u> (Thousands of Dollars)	<u>Current</u> <u>Estimate</u>	
Sensor definition and systems studies.....	---	---	---	6,000

OBJECTIVES AND STATUS:

The National Oceanic Satellite System (NOSS) offers a unique opportunity to collect global information on oceanic and atmospheric processes over its projected five-year lifetime. This information will be of immense value in addressing certain fundamental research questions, whose characteristic space and time scales require the global and synoptic coverage and long-duration data base that only a long-life satellite system such as NOSS can provide. Thus, NOSS represents a singular opportunity to look beyond today's operational data needs and to lay the basis for the future of satellite oceanography. The ability to forecast natural phenomena is contingent not only upon "monitoring" present sea surface conditions but also on scientifically sound basic research which links these satellite signals to the ocean's full three-dimensional structure and resultant behavior. In exploiting the unique opportunity afforded by NOSS for such research purposes, we will be providing the basic requisite tools to achieve this capability.

Long-term climatology, coastal disaster aversion, marine transportation, and fishing and pollution assessment are a few of the areas of national interest to be served by performing basic research utilizing data acquired by the NOSS spacecraft. As an example, we expect to gain an unparalleled understanding of the relation of large-scale wind fields with basinwide sea levels, and the resulting effects on some of the world's largest fisheries (e.g., Peruvian anchovy fishery). Such understanding would eventually lead to the capability to forecast regional fish catch, and consequently avert or minimize shortages of human and livestock food while conserving valuable energy resources.

FY 1982's activities will center on developing the criteria and selection recommendations for the most appropriate NOSS spacecraft instrument hardware modifications and/or additions, defining of the needed in situ tools (sensors and data acquisition systems), and the selection of data sets and analysis techniques which must be implemented into an Ocean Data Utilization System (ODUS) satisfying the national oceans research needs.

Specific short-term objectives are focused on providing a capability for the national oceanographic community to exploit the potential offered by NOSS for addressing fundamental research questions, which in turn will serve as the basis for addressing future oceanographic applications. Such questions involve relating scatterometer winds to wind-driven currents; microwave radiometry data to atmospheric water vapor; and color imagery to biological productivity and sediment transport.

A science working group has been formed to provide guidance and advice as how best to utilize the unique opportunity provided by NOSS. This group interfaces with the NOSS program through the NOSS Program Management Team. An ODUS subgroup, working under the science working group has been established, and in concert with other agencies (NSF, DOD/ONR, NOAA), is working to define the relevant data utilization requirements. Their final report is due during the summer of 1981 with some of the more critical assessments and recommendations coming sooner, e.g., recommendations on the research-oriented modifications to the NOSS primary sensor will be made by early 1981. Coordination with other agencies is being initiated relative to the definition and scope of the in situ instrumentation and ODUS.

BASIS OF FY 1982 ESTIMATE:

The major part of the FY 1982 effort will be devoted to initiation of the hardware implementation of the recommended NOSS operational instrument modifications which, together with additional research-oriented instrumentation, will occupy the 25 percent capacity of NOSS reserved for research purposes. This activity must begin no later than FY 1982 in order to avoid impact on the overall NOSS schedule. As preparation for this hardware implementation, sensor concept studies were initiated in 1980, and selected breadboarding and testing of the more promising concepts will have been completed by the end of 1981.

The additional instruments which complete the research payload will be selected in late 1981 and early 1982, and instrument design and specification studies will be undertaken then. In addition, studies for some of the in situ instrumentation (notably, drifting buoys) will have been completed by 1981, and preliminary engineering models will be constructed and tested in 1982.

Definition studies for the remainder of the in situ instrumentation must begin in 1982 to provide ample opportunity for them to be fully field-tested and deployed to allow utilization at the time of NOSS launch.

The hardware, software and systems studies necessary for the development of the ocean data utilization system configuration recommendations must begin in 1982 in order to allow implementation and test prior to the launch of NOSS. Specifically, data types, formats, storage, distribution and access requirements will be determined, and implementation technique development will be started. The architecture of the overall computing system will be developed in accordance with the determined needs of the oceanographic research community.

BASIS OF FY 1982 FUNDING REQUIREMENTS:**APPLICATIONS SYSTEMS**

	1980 <u>Actual</u>	1981 <u>Budget</u> <u>Estimate</u> (Thousands of Dollars)	Current <u>Estimate</u>	1982 <u>Budget</u> <u>Estimate</u>
Airborne instrumentation research program.....	15,567	18,100	18,100	14,400
Shuttle/Spacelab mission design and integration*.....	7,300	---	---	---
NASA integrated payload planning*.....	1,700	---	---	---
Total.....	<u>24,567</u>	<u>18,100</u>	<u>18,100</u>	<u>14,400</u>
Space transportation system operations				
For all space applications spacelab payloads.....	(100)	(8,600)	(1,700)	(14,500)

*Funding responsibility for FY 1981 and subsequent years has been transferred from Space Applications to Space Science.

OBJECTIVES AND STATUS:

The airborne instrumentation research program (AIRP) provides flight support to major segments of the space applications program. The aircraft fleet presently consists of two U-2C's, one WB-57F, one C-130, and one CV-990. These aircraft provide support as test beds for newly developed instrumentation and permit the demonstration of new sensor concepts prior to their being flown on satellites. The data acquired during the flights is used to refine algorithms and develop ground data handling techniques and preliminary proof of concept studies. Examples of such activities are flights over test sites to obtain crop signature data for the AgRISTARS program by the C-130 and flights in the U-2C's to acquire simulated thematic mapper data. A principal use of the WB-57Fs and U-2C's is to acquire stratospheric air samples and conduct in situ measurements at altitude ranges above the capability of more conventional aircraft and below that of orbiting spacecraft. This is important in the environmental observation program where much interest exists regarding stratospheric transport mechanisms and where it is extremely desirable to penetrate the stratospheric region--which in the tropical interconvergence zone is normally found at altitudes of 60,000 feet and above. During FY 1981, the ER-2 aircraft (U-2R) will be delivered. This aircraft is being obtained in conjunction with

a United States Air Force procurement and will replace one of the aging U-2's which will be returned to the Air Force inventory. The **ER-2** aircraft offers additional altitude and range capability and payload capacity over the U-2C. This enhanced capability should permit both more economical operation of the high altitude fleet and an improved capability to penetrate important regions of the stratosphere where there is considerable scientific interest.

BASIS OF FY 1982 ESTIMATE:

FY 1982 funds will provide the level of aircraft operations required to support the space applications program.

BASIS OF FY 1982 FUNDING REQUIREMENTS:

TECHNOLOGY TRANSFER

	1980	1981		1982
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of Dollars)		
Applications systems verification and transfer.....	1,700	600	1,400	1,000
Regional remote sensing applications.....	3,655	1,800	2,700	2,600
User requirements and supporting activities.....	<u>4,732</u>	<u>5,100</u>	<u>6,000</u>	<u>5,400</u>
Total.....	<u><u>10,087</u></u>	<u><u>7,500</u></u>	<u><u>10,100</u></u>	<u><u>9,000</u></u>

OBJECTIVES AND STATUS:

The objectives of the technology transfer program are to provide for the development, validation, transfer and dissemination of remote sensing technology applications for operational use by public and private organizations.

The applications systems verification and transfer (ASVT) program conducts joint projects with users to develop remote sensing applications, verify that these applications are sufficiently developed for operational use, and transfer the vetified applications to representative operational users. The program emphasizes cost reduction and adaptive engineering to ensure compatibility with the users needs. Projects conducted under the program apply remote sensing technology to the operational tasks of other federal agencies; state, local and regional governments; and private sector users. Projects are now underway with the National Park Service, Pacific Northwest Regional Commission, the States of Alaska and California, and regional water management districts in the State of Florida. Additional projects will be undertaken in FY 1981 with the Missouri River Basin Commission and with Pacific Gas and Electric Company.

The regional remote sensing applications program provides for cooperative efforts with state and lcoal governments to evaluate proven Landsat applications in natural resource and environmental management. The program has provided major impetus to state use of Landsat data through data analysis training to over 1500 state, local and Federal personnel and the completion of fifteen multidisciplinary state application demonstration projects. Follow-on technical assistance in the use of NASA software has lead to the establishment of operational Landsat data processing capabilities in fourteen

states. Projects with another fourteen states are presently being conducted. Significantly increased technical communications and cooperation among states, as well as encouragement for state use of private sector capabilities is being stimulated through user documentation, quarterly newsletters, and a series of user symposia to be held in the spring of 1981. Increased use of geobased information systems in the regional transfer projects has increased the relevance and utility of Landsat data utilization to other state programs. A pilot program of cooperative projects has been initiated to involve county and other local government organizations in the evaluation and use of Landsat data both independently and through the use of established state capabilities. The National Association of County Officials is participating in this activity through evaluation of county user experiences with Landsat, analysis of county government needs, and information programs to make counties better aware of Landsat data utility.

Under user requirements and supporting activities, continuing communications at the national level are maintained between NASA and the user community to determine and analyze national priorities and user needs, inform users of existing and planned technological capabilities, obtain external evaluations of technology transfer programs for planning purposes, and develop program awareness and technical capabilities in educational institutions. The user requirements and supporting activities liaison with state governments has been maintained through cooperative arrangements with the National Conference of State Legislatures (NCSL) and the National Governors Association (NGA). These groups have participated in planning for the national operational land remote sensing system. This year similar communication links will be established with substate government organizations such as the National Association of County Officials (NACO) and the National Innovation Network. Liaison has also been established with a major private sector user/service organization (American Society of Landscape Architects). Studies this year were performed to evaluate private user needs and address major needs categories through joint transfer projects thereby providing private companies (power utility industry) an opportunity to use remotely sensed data in increasing their own productivity. A program to increase transfer to locally-based private industries including architectural and engineering firms, environmental and development consultants, and data processing companies, is being implemented through a network of community colleges. A systematic requirements analysis procedure was initiated to direct future transfer efforts to those application/user areas with highest payoff. A user needs assessment will be completed this year for coastal zone management using this procedure. As a result of continuing university applications activities, 25 university remote sensing centers have been established to date and continue to play a significant role in assisting in the development of state operational capabilities. Addition of a geology center in FY 1980 complements previous discipline centers established in geodynamics and materials processing.

CHANGES FROM FY 1981 BUDGET ESTIMATES:

The \$2.6 million increase in FY 1981 for technology transfer is the result of a Congressional increase to the budget request. These funds will provide for program increases in the development of satellite remote sensing applications evolving from research and development programs and the transfer of these applications to operational use by state and local governments and private industry.

BASIS OF FY 1982 ESTIMATE:

Major emphases for FY 1982 will be in the following areas:

ASVT projects with the States of Alaska and California and with regional water management districts in the State of Florida will be completed in FY 1982. In FY 1982, two new ASVT's will be initiated. Program thrusts for FY 1982 will be in the application of remote sensing technology to water resource management activities (coastal zone, waste water, and reservoir management) and to large-scale private sector engineering and construction projects.

In FY 1982, the regional remote sensing applications program will provide for completing cooperative projects already initiated or committed in ten states as well as the follow-up technical assistance necessary to complete technology transfer to these ten states. Introductory, multidisciplinary projects will be undertaken selectively with the remaining states because adequate assistance is expected to be available from universities, private industry, and other states at that time. Transfer to operational users will continue through special purpose workshops and selective applications development projects focusing on specific new technologies (preparation for thematic mapper, low cost systems, improved analytical techniques) and specific discipline areas (water resources, soil erosion, coastal zone management) which represent high priority user needs. Final decisions on discipline area emphasis will be based on the results of FY 1981 user evaluations. Transfer programs with substate users, such as county government, will continue at a pilot level in cooperation with the National Association of County Officials and other user representative organizations.

User requirements and supporting activities will focus on user awareness of evolving remote sensing capabilities and assessment of user requirements for improved technology through continuing cooperative arrangements with the National Conference of State Legislatures and the National Governors Association. Discipline oriented technology requirement studies will be continued and a strategy of technology transfer to the private sector and substate governments (in concert with the National Association of County Officials) will be implemented. Activities will be conducted to support NOAA in the transition of Landsat to an operational land remote sensing system. These activities will include: the co-sponsorship of user symposia and workshops to tie NOAA into established user networks; conducting user requirements studies; and activities to continue increasing user awareness of remote sensing capabilities. In university applications, support will be continued for the remaining thirteen university remote sensing centers and the four established basic research centers. However, no new university grants will be initiated during FY 1982.

BASIS OF FY 1982 FUNDING REQUIREMENTS:**MATERIALS PROCESSING IN SPACE**

	1980	1981		1982	Page
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>	<u>No.</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>	
		(Thousands of Dollars)			
Applied research and data analysis.. .. .	7,200	11,700	10,950	14,000	RD 7-61
Shuttle/spacelab payload development.. .. .	10,468	10,500	10,750	12,000	RD 7-63
Materials experiment operations..... .	(533)	(2,400)	(1,900)	6,100	RD 7-65
Space processing applications					
rocket (SPAR) project	<u>2,100</u>	<u>---</u>	<u>---</u>	<u>---</u>	<u>---</u>
Total.....	<u>19,768</u>	<u>22,200</u>	<u>21,700</u>	<u>32,100</u>	

OBJECTIVES AND STATUS:

The materials processing in space program emphasis is on the fundamental science and technology of processing materials to understand constraints imposed by gravitational forces and the enhancement possible in the control of these processes through the use of the space environment. The goal is to test and demonstrate the unique characteristics of the space environment for materials processing. As these development, test, and demonstration efforts proceed, the technology will be transferred as appropriate to non-NASA users for their use.

Ground-based research, technology development, and payload definition activities in FY 1982 will concentrate on three major processing areas: crystal growth and solidification, containerless processing, and fluid and chemical processing. Also, limited research will be supported in the areas of cloud physics, combustion science, vacuum science, fluid dynamics and extraterrestrial materials science. These activities will provide the scientific basis for future space applications of materials processing technology. Definition study activities will be performed for Shuttle payload candidates such as the acoustic containerless experiments system, the combustion science system, the containerless measurement system, and the floating zone experiment system.

The Shuttle/Spacelab payload development project will provide opportunities to perform materials science experiments in an extended, microgravity environment. Fabrication and testing of the fluid experiment system, vapor crystal growth system and monodisperse latex reactor will be completed in FY 1981. The solidification experiment system has been re-phased due to technical difficulties so that a development test article will be developed and tested in FY 1981 prior to initiating fabrication of the flight article in FY 1982 to verify its performance against experiment requirements and the analytical mode.

Materials experiment operations is a consolidation and expansion of ongoing activities which provide a range of experimental capabilities for all scientific and commercial participants in the materials processing in space program. These include drop towers and aircraft and sounding rocket flights as well as the Shuttle mid-deck experiments and the material experiment assembly. These capabilities will allow users to begin experiments early in a cost-effective manner and allow NASA to develop a better understanding of the technical risks associated with experiment concepts before attempting to develop more complex hardware. In addition, limited reflight of currently selected investigations on sounding rockets and on Shuttle/Spacelab missions is included in materials experiment operations.

The Space Processing Applications Rocket (SPAR) project has been completed with the ninth and final flight flown in January 1981. Further use of sounding rocket experiments will be included as part of the FY 1982 materials experiment assembly, which will be placed in bonded storage in FY 1981. Research investigations associated with SPAR will be supported as a part of materials experiment operations in FY 1981.

Applied Research and Data Analysis (Materials Processing)

	1980 <u>Actual</u>	1981 <u>Budget</u> <u>Estimate</u> (Thousands of	1981 <u>Current</u> <u>Estimate</u> Dollars)	1982 <u>Budget</u> <u>Estimate</u>
Ground-based investigations, analysis, and studies.....	7,200	11,700	10,950	14,000

OBJECTIVES AND STATUS:

The applied research and data analysis (AR&DA) activity provides the scientific foundation for all current and future projects in the materials processing in space program. The emphasis is placed on ground-based research which is expected to develop into space investigations with potential for future applications. In addition, the AR&DA program supports technology development for future ground and space capabilities, equipment definition studies responding to

identified space experiment needs, and commercialization activities toward space enterprises involving private industry. Most research projects in the AR&DA program are initiated as a result of unsolicited proposals from the scientific community, which are extensively peer reviewed prior to selection. The N 1981 funding has been used to initiate funding of another set of new three-year research projects proposed by leading members of the materials science community; initiate new activities in electrostatic containerless processing, combustion science, and extraterrestrial materials processing; and to begin definition studies in the acoustic containerless experiments system and combustion science facility. Ongoing research, which will continue in N 1982, concentrates on scientific investigation and technology advancement in infrared detector materials, inertial confinement fusion targets, floating zone crystal growth, separation and synthesis of biological materials, fluid flow effects in materials processes, combustion science, vacuum science, containerless processing techniques and extraterrestrial materials processing. In addition, some cloud physics research will be initiated as low-gravity research opportunities become available. Commercialization activities will continue with studies of institutional, legal, and economic issues of joint NASA/industry ventures, information activities directed toward industry involvement in materials processing in space projects, and negotiations with companies in undertaking joint space endeavors with NASA.

CHANGES FROM FY 1981 BUDGET ESTIMATE:

Reallocation of \$250,000 was required in FY 1981 to provide for requirements associated with the rephasing of the Shuttle payload development. In addition, a reduction of \$500,000 in this project is related to the overall Congressional reduction in the NASA appropriation request. The initiation of some new investigations under AR&DA will be deferred until N 1982.

BASIS OF FY 1982 ESTIMATE:

FY 1982 funding will continue the ground-based research program, which is now identifying requirements for extensive space experimentation in crystal growth, flows in weightless fluids, density-gradient driven convection, controlled solidification processes, containerless processing, and separation processes for biological materials. New activities will be undertaken in cloud physics, combustion science.

Continuing definition activities in FY 1982 will include an analysis of accommodations on simple free-flying facilities in low-Earth orbit to fulfill projected requirements for the McDonnell-Douglas pilot plant that will evolve from the joint endeavor project in 1986. Studies of simple materials processing in space payloads, which can be operated autonomously, will also be conducted. Definition studies in space materials systems will be initiated, leading to the development of technologies for converting extraterrestrial materials cost-effectively into useful forms for both space and terrestrial applications. In addition, studies of a floating zone experiments system will be undertaken which will be configured with direct industrial consultation. Hardware definition will begin for the containerless measurements experiments system and the isoelectric focusing separation system, and will continue for the combustion science facility.

AR&DA funding for N 1982 will provide for increased effort in advanced technology development to meet needs identified in the ground-based research program, and for definition studies on space experiment systems needed to perform investigations arising from materials processing in space research. Materials processing technology will be developed in areas such as automated sample exchange; electromagnetic, acoustic, and electrostatic levitation; materials property measurements; holography; and the production and purification of biological materials.

Commercialization activities will be continued in FY 1982 with the development of joint exploration research programs with industry using NASA ground-based experiment facilities. This popular approach to joint involvement of industrial researchers on a no-exchange-of-funds basis is expected to generate more extensive commitments to future use of Shuttle/Spacelab capabilities.

Shuttle/Spacelab Payload Development (Materials Processing)

	1980 <u>Actual</u>	1981		1982 <u>Budget Estimate</u>
		<u>Budget Estimate</u>	<u>Current Estimate</u>	
		(Thousands of Dollars)		
Payload development.....	9,935	8,100	8,850	12,000
Experiment operations.....	533	2,400	1,900	---*
Total.....	<u>10,468</u>	<u>10,500</u>	<u>10,750</u>	<u>12,000</u>

*Included under Materials Experiment Operations

OBJECTIVES AND STATUS:

The space processing Shuttle/Spacelab payload development project includes the design and development of a basic set of payload equipment for space experiments on materials and processes, and provides for conducting experiments with this equipment on space transportation system (STS) flights. The first series of experiments to use the equipment will be flown on the Spacelab-3 mission and a pallet mission, both currently scheduled in 1984. Investigations selected for these flights cover topics in crystal growth, fluid flow effects, physical metallurgy, specialized composite materials, and polymerization. All of the equipment is being designed for repeated use and a long service lifetime, so that it can be used for further experiments on later missions without new development or substantial modification.

Four equipment systems are under development. **Two** of these are multiuser facilities: the fluid experiments system (FES), a sophisticated holographic optical measurement system to determine density gradients and fluid flows during crystal growth and analogous processes; and the Solidification Experiments System (SES), a versatile electric furnace system capable of performing a wide range of controlled high temperature melting and freezing experiments. The other two systems are being built specifically for individual investigations: the Vapor Crystal Growth System (VCG) will grow large single crystals of mercuric iodide by evaporation and recondensation; and, the Monodisperse Latex Reactor (**MLR**) will be used to study the kinetics of latex particle growth under conditions that produce particles of uniform size.

The development schedule for SES has been rephased due to technical difficulties. Prior to initiation of flight hardware, a test article will first be developed and tested in FY 1981 to verify its performance against experiment requirements. Assuming the performance of the test article meets the experiment requirements, the flight hardware will be developed in FY 1982. The resulting SES will include an advanced state-of-the-art furnace system which will take advantage of the reduced convection in space and enable fully programmable control over the shape, position, and speed of advance of crystal growth and solidification solid/melt interfaces.

CHANGES FROM FY 1981 BUDGET ESTIMATE:

The net increase of \$250,000 in payload development activities in FY 1981, together with an adjustment between the project elements, was necessary to provide for current requirements resulting from the rephasing of the SES development schedule. This adjustment was possible due to the revised Shuttle flight schedule.

BASIS OF FY 1982 ESTIMATE:

Final fabrication and testing will be completed for the FES and VCG, which will then be placed in bonded storage to await the first scheduled flight in 1984. Final design and initial development of the SES will be performed leading to delivery for Shuttle pallet integration in late 1983. Principal investigators will participate in all testing and complete development of their flight experiment protocols and samples for the first missions.

Materials Experiment Operations

	1980 <u>Actual</u>	1981 <u>Budget Estimate</u> <u>Current Estimate</u> (Thousands of Dollars)		1982 <u>Budget Estimate</u>
Materials experiment operations.....	(533)*	(2,400) *	(1,900)"	6,100

*Included under materials processing Shuttle/Spacelab payload development

OBJECTIVES AND STATUS:

Materials experiment operations provide a range of opportunities for scientific and commercial experimenters in material processing in space which will enable them to gain experience in a cost-effective manner and enable NASA to better understand the technical risks associated with their experimental concepts before attempting to develop more complex hardware. Such facilities are generally already in use and include drop towers, drop tubes, aircraft and sounding rocket flights. Development of Shuttle mid-deck experiments and the first materials experiment assembly (MEA) accommodations will be completed in CY 1981.

In addition, reflights of existing Shuttle/Spacelab facilities and the selection of a limited number of new investigations for the FES will be possible.

BASIS OF FY 1982 ESTIMATE:

Additional drop capabilities will be made available for performing experiments on new metal alloy structures and the nucleation phenomena producing them. Experiments to study the formation processes of glass shells for inertial confinement fusion targets will also be conducted. Additional KC-135 and F-104 aircraft flights which allow for 20 to 40 seconds of low gravity experiment time will be provided in FY 1982. One sounding rocket flight will be possible in FY 1982 as an outgrowth of hardware and scientific investigations developed under the previous SPAR program.

Several small experiment packages will be developed from current requirements during FY 1982 for flight on the Shuttle mid-deck area. These packages will use existing hardware from the sounding rocket program to as large an extent as possible to provide for extended experiment time required for most investigations. The materials experiment assembly (MEA-I) will be refurbished for its second flight by purchase of necessary components and analytical studies of the new experiment complement. Development of a second generation MEA-II, which will use STS power and cooling capability rather than relying on its own capabilities as in MEA I, will be initiated. Several potential flight opportunities have been planned for both versions of MEA which make a second unit mandatory because of the short turnaround times involved in flight availability. In addition, there is identified commercial interest in MEA-II which is dependent on its development in FY 1982.

BASIS OF FY 1982 FUNDING REQUIREMENTS:**COMMUNICATIONS AND INFORMATION SYSTEMS**

	1980	1981		1982	Page
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>	<u>No.</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>	
		(Thousands of Dollars)			
Search and rescue mission.....	2,530	2,300	4,800	5,000	RD 7-68
Technical consultation and support studies.....	3,182	3,200	3,100	3,600	RD 7-70
Applied research and data analysis.....	6,200	16,600	16,600	15,400	RD 7-71
Experiment coordination and operations support.....	3,583	2,300	2,200	1,000	RD 7-73
Data systems program.....	3,100	4,600	4,500	10,600	RD 7-74
Adaptive multibeam phased array.....	<u>1,660</u>	<u>---</u>	<u>---</u>	<u>---</u>	<u>---</u>
Total.....	<u>20,255</u>	<u>29,000</u>	<u>31,200</u>	<u>35,600</u>	

OBJECTIVES AND STATUS:

The objective of the communications and information systems program is to provide the technology to permit new and low-cost services to the public by ensuring the most effective use of the geosynchronous orbit and radio frequency spectrum and by conducting the program in such a way that the preeminent position of the United States industry in the market will be sustained. In FY 1980, multiyear contracts were placed with United States industry to establish a strong technology base for use of the 30/20 GHz band to support a flight system demonstration in the later 1980's. These efforts, which **will** be completed in FY 1982, will produce proof-of-concept model hardware of multibeam antennas, on-board switching, signal processing, and radio frequency components. In FY 1980, preproject system studies were initiated to determine the relationships among system capability, size, architecture and costs for a wide range of space and ground configurations. The results of these system studies, which will be completed in FY 1981, will provide a broad and detailed data base for the flight project phase of the 30/20 GHz portion of the communications program.

The search and rescue program, using satellites to aid in the detection and location of distress beacons carried by aircraft and ships, will begin its demonstration and evaluation phase in 1982 with the launch of the first United States spacecraft in the series, NOAA-E, and the Soviet satellite, COSPAS 1. During FY 1981, the NOAA-E spacecraft will be completed and the search and rescue antennas, receivers, signal processor and transmitter will be integrated and tested, completing all necessary preparations for launch. **Also** in FY 1981, the ground station development will be completed and three ground stations will be installed at search and rescue facilities operated by the United States Coast Guard (2) and the United States Air Force. Experimental distress transmitters operating at **406** MHz will be completed and deployed in accordance with the demonstration and evaluation plan. This work will be done in cooperation with Canada, France, and the U.S.S.R. The search and rescue program is now planned to span the balance of this decade with payloads aboard six meteorological spacecraft operated by the National Oceanic and Atmospheric Administration, and at least two Soviet COSPAS spacecraft. NASA will continue to advance the technology of this system to lower the equipment cost and thereby increase the availability of this service to the public.

Technical consultation and support studies will continue to provide radio interference, propagation and special system studies required for the growth of existing satellite services and the inclusion of new satellite applications. Special emphasis will be placed **on** geostationary orbit and spectrum congestion and **on** assessing the impact of the 1979 General World Administrative Radio Conference (GWARC) **on** present and future telecommunications and remote sensing. Orbit and spectrum utilization studies include the development of frequency and orbit sharing techniques and strategies, design standards, and the determination of the effects of propagation phenomena and man-made noise **on** performance, design, and efficient use of the geostationary orbit and radio spectrum. These studies are essential to a broad range of public and private sector applications such as commercial mobile telephone, disaster communications, law enforcement, health and education, interstate commerce, and terrorism control. **In** a broader sense, the capabilities will be invaluable for domestic and international economic and social development.

During FY 1981, work will continue with the National Telecommunications and Information Administration, Department of Commerce (NTIA) and its Interagency Committee on Satellite Telecommunications Applications, representing 18 Federal agencies. Emphasis will be **on** identifying technology development that could enable industry to meet more effectively the growing communications needs of Federal agencies. NASA will support the continued operations of Applications Technology Satellites-1, -3, and -5, while providing for the orderly phaseout of former experimental satellite demonstrations, and will provide for the continuing transition of Federal public service communications activities from NASA to the NTIA.

FY 1982 funds will support essential activities for inventorying, cataloging and managing space and terrestrial applications data bases. The atmospheres, oceans and resource pilot data system projects initiated during FY 1980 and FY 1981 will be continued to provide test beds for developing and evaluating new data systems standards and data management capabilities. Preliminary definition of an Applications Data Service (ADS), a data sharing network service, will be completed during FY 1982. In addition, the FY 1982 funds will support data systems research and development activities leading to the solution of future high volume data processing problems, to the development of transportable software systems, and to the future implementation of a full capability ADS.

Search and Rescue Mission

	1980 <u>Actual</u>	1981 <u>Budget</u> <u>Estimate</u> (Thousands of Dollars)	1981 <u>Current</u> <u>Estimate</u>	1982 <u>Budget</u> <u>Estimate</u>
Search and rescue basic mission.....	2,530	2,300	4,800	1,300
Search and rescue operational evaluation phase.. ..	<u>---</u>	<u>---</u>	<u>---</u>	<u>3,700</u>
Total.....	<u>2,530</u>	<u>2,300</u>	<u>4,800</u>	<u>5,000</u>
Atlas (expendable launch vehicles program).. ..	(1,200)	(---)	(---)	(---)

ECT AND STATUS:

The objective of the search and rescue mission is to demonstrate the feasibility of using satellites to provide a significant improvement in the capability of search and rescue forces to detect and locate distress signals from general aviation aircraft and marine vessels during emergencies. System studies have shown that a satellite orbiting at an 850-kilometer altitude can detect the emergency beacons operating at 121.5 and 243 MHz presently carried by aircraft and ships. Systems analysis and simulations indicate that the satellite can fix the position of these beacons to an accuracy of about 15-20 kilometers, and could locate a proposed new beacon (using the recently-allocated 406 MHz frequency), with its stronger and more stable signal, to about 5 kilometers. The experiment will permit rescue forces to arrive at the accident scene more quickly than is presently possible, because of the more comprehensive coverage a satellite system can provide compared to the irregular coverage provided by overflying aircraft now relied upon.

The international interagency program is being conducted jointly with Canada, France, and the Soviet Union. The United States will provide the spacecraft, antennas, development of the **406 MHz** emergency, locator transmitter, and the United States ground stations; the Canadians will provide the space telecommunications equipment and a ground station in their country; and France will provide an onboard processor and receiver. The Soviet Union will launch and maintain in orbit two spacecraft operationally compatible with the United States, French, and Canadian system and will operate their own ground stations. The Departments of Defense and Transportation are expected to purchase and operate ground stations and participate in the program test and evaluation phase, while NOAA is providing the spacecraft for modification.

The design of the spacecraft modifications to accommodate the search and rescue instrumentation and the design of the required spacecraft antennas have been completed. Fabrication of the spacecraft and antennas **is** nearly complete. A new, improved **406 MHz** emergency locator transmitter is currently being developed. The local user terminal and the United States mission control center are also under development. All activities required to support a mid-1982 launch are proceeding on schedule.

CHANGES FROM 1981 BUDGET ESTIMATE:

The increase of \$2.5 million in FY 1981 results from the restoration of funds transferred from search and rescue **in** FY 1980 to cover unanticipated Landsat-D requirements.

BASIS OF FY 1982 ESTIMATE:

FY 1982 funding will be used to complete spacecraft launch preparations for NOAA-E and to conduct the beginning of the demonstration and evaluation phase activity. **In** addition, work will begin on the extended "operational evaluation" phase of the program. This phase of the program will permit an uninterrupted transition from a successful demonstration to a fully operational follow-on system, eliminating the possibility of a most undesirable break in coverage in the very likely event that the system proves useful in the actual saving of lives during the demonstration and evaluation phase. The major element of this extended transition program is the provision of search and rescue equipment on three additional NOAA spacecraft, NOAA-H, -I and -J, providing continuous spacecraft coverage through most of the 1980's. This will allow sufficient time for the operational system to be approved, funded, and deployed. Additionally, advanced technology will be applied to the development of low-cost emergency transmitters which will not only result in more widespread use of the satellite system but will also provide a competitive edge to United States suppliers in meeting the large international demand for these transmitters during the operational era.

Technical Consultation and Support Studies

	1980 <u>Actual</u>	1981 <u>Budget</u> <u>Estimate</u> (Thousands of Dollars)	<u>Current</u> <u>Estimate</u>	1982 <u>Budget</u> <u>Estimate</u>
Technical consultation and support studies.....	3,182	3,200	3,100	3,600

OBJECTIVES AND STATUS:

The growth of existing satellite service and new satellite applications require radio interference, propagation and system studies which are being conducted under this program. NASA's unique technical expertise is also used to support organizations such as the Federal Communications Commission, National Telecommunications and Information Administration, and the Department of State, where consultation with NASA is required by various statutes and directives, such as the Communications Satellite Act of 1962 and Presidential Directive 42. Analytical tools are developed and used to solve problems of inter- and intra-system interference. They provide a technical basis for regulatory and policy studies needed to enable continuing, orderly growth of existing and new satellite service. The main elements of the program consist of orbit and frequency utilization, propagation and interference effects, and spacecraft systems studies and measurements.

Major project emphasis was placed on the 1979 World Administrative Radio Conference (WARC). Through studies and consultation, NASA played a key role in the preparation for and participation in the conference, and is presently involved in a post-WARC assessment. NASA's technical studies were crucial in the WARC's decision to preserve critical frequency allocations for remote sensing, and protect them from other communications satellite interference. Prior to the WARC, there were no practical allocations designated for the land mobile satellite service. Similar accomplishments were achieved in other areas. As a result of these efforts, primary allocations were obtained, worldwide. More than 100 technical and position papers on these and other subjects were provided in support of the WARC.

The results of the program have made it possible to implement, on a commercial and nonexperimental basis, remote sensing, mobile communications and broadcasting by satellite. These capabilities are essential to a broad range of public and private sector applications such as commercial mobile telephone, disaster communications, law enforcement, health and education, interstate commerce, and terrorism control. In a broader sense, the capabilities will be invaluable for domestic and international economic and social development.

CHANGES FROM FY 1981:

A reduction of \$100,000 is due to the overall Congressional reduction in the FY 1981 NASA appropriations request.

BASIS OF FY 1982 ESTIMATE:

Major emphasis over the next 2-3 years will include preparations for the 1984/86 World Administrative Radio Conference on Geostationary Orbit Planning, the 1983 Western Hemisphere Conference on Broadcast Satellite Planning, and the 1982 WARC on Mobile Communications; development of solutions to problems of geostationary orbit and spectrum congestion over the North American continent; development of propagation effects models for the NASA 30/20 GHz program and for fixed broadcast applications of 14/12 GHz bands; completion of propagation studies for mobile satellite communications; completion of conceptual descriptions and traffic models of thin-route narrowband communications systems for regulatory purposes; and development of concepts of mechanisms to facilitate the transition of experimental programs to the commercial sector.

Applied Research and Data Analysis (Communications)

	1980 <u>Actual</u>	1981 <u>Budget</u> <u>Estimate</u> (Thousands of Dollars)	<u>Current</u> <u>Estimate</u>	1982 <u>Budget</u> <u>Estimate</u>
Wideband 30/20 GHz definition.....	1,024	1,200	1,900	---
Advanced communications research.....	5,176	5,400	4,700	5,400
Advanced technology development.....	---	<u>10,000</u>	<u>10,000</u>	<u>10,000</u>
Total.....	<u>6,200</u>	<u>16,600</u>	<u>16,600</u>	<u>15,400</u>

OBJECTIVES AND STATUS:

The objective of applied research and data analysis (AR&DA) is to develop the technology base and related supporting studies that are the foundation of the joint NASA/United States industry 30/20 GHz program.

AR&DA comprises market studies, preliminary system concept studies, and development of technologies critical to relief of the geostationary arc and frequency congestion problems, now becoming increasingly apparent. Currently, there are

nine United States domestic communications satellites located above the Equator in view of the United States, with applications on file for 24 more to be launched by the mid-1980's. These satellites will exhaust the capacity of the orbital arc and the lower frequency bands which must support both foreign and domestic communications satellites. Capacity increases beyond the mid-1980's will require the technology advances that the 30/20 GHz program will develop. By sponsoring these major technological advances, the program also substantially strengthens United States industry against foreign competition from well-financed and carefully-planned government/industry teams in Japan and Western Europe.

Initial system concepts have identified two systems utilizing the component technologies described below. One would provide wideband trunking services between major United States cities, while the second would provide more modest services between a large number of small terminals located at the users facility ("customer-premise" service). These two system approaches have now evolved to a single spacecraft concept capable of demonstrating the major elements of both types of service.

In parallel with these system studies, a number of technology development contracts have been awarded to United States industry to produce proof-of-concept models of components and subsystems required to permit satellite communications operations in this new frequency band. Contracts have been awarded in the following technology areas: multiple spot-beam spacecraft antennas, spacecraft matrix switch for trunking applications, baseband spacecraft processor, 30 GHz spacecraft receiver, 20 GHz solid state (GaAsFET) spacecraft transmitter, 20 GHz spacecraft traveling-wave tube amplifier, 20 GHz traveling-wave tube power supply, 30 and 20 GHz latching switches, switches and filters for spacecraft-switched multiple access systems, components for low-cost ground terminals, and spacecraft transponders.

All but the last three of these elements are now under contract with dual competitive contracts in most cases. The proof-of-concept models produced by these contractors are scheduled for delivery in FY 1981 and 1982 and will undergo extensive component and integrated, system-level testing to evaluate their readiness for flight demonstration.

To an extent unparalleled in previous satellite programs, close cooperation has been maintained with aerospace manufacturers, communications common carriers, and user organizations to ensure that the technology in the 30/20 GHz program meets the needs of the Nation in satellite communications.

CHANGES FROM FY 1981 BUDGET ESTIMATE:

Wideband 30/20 GHz project definition funds were increased by \$700,000 in FY 1981 to permit increases in the number of system definition studies required to develop a less-costly single flight demonstration concept in place of the two separate flight demonstrations previously contemplated. An offsetting reduction in the funding of advanced communications research was realized by small adjustments in the technology development tasks performed under that activity.

BASIS FOR FY 1982 ESTIMATE:

The primary thrust of AR&DA continues to be focused on the enabling technology required for advanced 30/20 GHz communication satellite systems. Proof-of-concept models of all components and subsystems will be completed during FY 1982, and will be delivered for laboratory compatibility testing. Their readiness and suitability for operational use in a flight demonstration of an advanced communications satellite later in the 1980's will be assessed.

Experiment Coordination and Operations Support

	1980 <u>Actual</u>	1981 <u>Budget</u> <u>Estimate</u> (Thousands of Dollars)	1981 <u>Current</u> <u>Estimate</u> (Thousands of Dollars)	1982 <u>Budget</u> <u>Estimate</u>
Experiment coordination and operations support.....	2,398	1,400	1,400	1,000
Applications pilot test.....	<u>1,185</u>	<u>900</u>	<u>800</u>	<u>---</u>
Total.....	<u><u>3,583</u></u>	<u><u>2,300</u></u>	<u><u>2,200</u></u>	<u><u>1,000</u></u>

OBJECTIVES AND STATUS:

The objectives of this program are to continue experiment support for ATS-1, -3, and -5; and to complete, appropriately document, and archive the wide range of user experiments and demonstrations in the application of satellite communications. Past experiments with NASA experimental satellites (ATS series and CTS) have generated great interest nationally and internationally in satellite telecommunication. Nearly 400 communications experiments using the ATS series and CTS have been successfully conducted during the extended lifetimes of these satellites to provide user experience for making decisions regarding their communications functions. NASA's stimulus in encouraging use of these unique facilities has led to wider use of commercial satellites, which can now better meet needs for flexibility and continuity of services. Public service user experiments on ATS-6 and CTS were completed on June 30, 1979. Complete reports on experiment results will be prepared for use by the many interested groups that could not directly participate.

CHANGES FROM FY 1981 BUDGET ESTIMATE:

The net reduction in FY 1981 of \$100,000 is a result of the overall Congressional reduction in the NASA appropriation request. Current FY 1981 applications pilot test funds are reduced from the budget estimate because several tasks planned for implementation in FY 1981 were initiated with FY 1980 funding. The applications pilot test program plan is not affected by these changes.

BASIS OF FY 1982 BUDGET ESTIMATE:

Activity in experiment support for **ATS-1** and **-3** will continue in FY 1982, and final engineering tests for **ATS-5** will be completed and reported. Applications pilot test activities will not be continued in FY 1982; however, several related public service satellite applications studies are planned, including Ku-band (14/12 GHz) satellite network development, educational telecommunications applications, and transportable Earth terminal modifications.

Data Systems Program

	1980	1981		1982
	Actual	Budget Estimate	Current Estimate	Budget Estimate
		(Thousands of Dollars)		
Applications data service definition.....	2,245	3,000	3,000	---
Data management.....	855	1,600	1,500	---
Data systems program.....	---	---	---	10,600
Total.....	<u>3,100</u>	<u>4,600</u>	<u>4,500</u>	<u>10,600</u>

OBJECTIVES AND STATUS:

The data management and applications data service definition activities, carried as separate supplements in the space communications request for FY 1981, have been integrated into an overall data systems program in the space communications request for FY 1982. This change integrates management of data systems research and development activities under one program within the communications and information systems division.

The overall objectives of the data systems program are to develop advanced capabilities for processing, managing and registering data and information; implement data systems standards and transportable software systems to lower data

system costs; and develop an applications data service (**ADS**) to provide improved access to, and rapid delivery of, space applications data and information in support of the Nation's remote sensing program.

The program provides for timely development of data systems capabilities to meet the initial needs of flight missions and major applications programs. This approach will reduce ground data systems development risks and the incidence of data system cost overruns, schedule slips and late data delivery. The results of the FY 1982 efforts will provide for an earlier return on our considerable investment in data acquisition, will establish a firm basis for interagency data sharing, and will result in compatible data and data systems. An intensive interagency workshop was conducted in FY 1980 to define the needed pilot tests that will provide the basis for the evolutionary development of an **ADS**. Pilot data system projects were initiated in FY 1980 (and will continue during FY 1981) in the atmospheres, oceans and resources disciplines. The pilots are developing and demonstrating common approaches for cataloging, processing, managing, and registering multi-disciplinary applications data.

CHANGES FROM FY 1981 BUDGET:

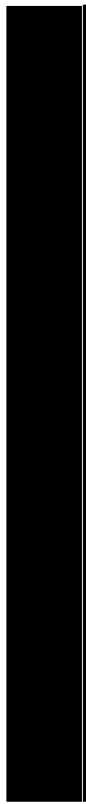
The net reduction of \$100,000 is a result of the overall Congressional reduction in the FY 1981 NASA appropriation request.

BASIS FOR FY 1982 ESTIMATE:

The FY 1982 data systems program will focus on developing common data formats; new and more uniform system approaches to cataloging, registering, and managing space applications data and information; transportable software systems to lower software costs and foster transferability of software packages between systems; advanced high speed processing systems and system concepts to cope with the higher volume data processing requirements of future missions; and use of advanced technologies such as optical disks and fiber optic telecommunication links to lower costs for data storage, data handling and rapid data delivery.

The FY 1982 program allows orderly and steady progress toward establishing the data system R&D base needed to improve capabilities for analyzing, managing and exchanging data and information in support of the space applications projects. It allows completion of the **ADS** definition studies; supports the continuation of the three existing pilot data system projects through completion; provides for the interconnection of the existing pilots to form the nucleus of an **ADS**; supports near term implementation of advanced data systems technology; provides for technical support of flight projects; continues high priority data management, data system standards and transportable software research and development activities; and allows the definition of joint pilot activities with the National Bureau of Standards and NOAA. The FY 1982 program also prepares the groundwork leading to the solution of future, high-volume data processing problems and to the future implementation of a full capability **ADS**.

TECHNOLOGY
UTILIZATION



RESEARCH AND DEVELOPMENT

FISCAL YEAR 1982 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE AND TERRESTRIAL APPLICATIONS

TECHNOLOGY UTILIZATION PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1980 <u>Actual</u>	1981 <u>Budget Estimate</u> <u>Current Estimate</u> (Thousands of Dollars)		1982 <u>Budget Estimate</u>	Page <u>No.</u>
Technology dissemination	3 700	4 100	4 000	4 600	RD 8-4
Technology applications	4 400	3 800	3 800	5 300	RD 8-4
Program evaluation and support	1 480	1 600	1 500	1 800	RD 8-4
Civil systems	<u>2 400</u>	<u>2 600</u>	<u>2 500</u>	<u>2 900</u>	RD 8-5
Total	<u>11.980</u>	<u>12.100</u>	<u>11.800</u>	<u>14 600</u>	

DISTRIBUTION OF PROGRAM AMOUNT BY INSTALLATION:

Johnson Space Center	10	150	100	150
Kennedy Space Center	79	150	100	150
Marshall Space Flight Center	392	490	500	540
National Space Technology Laboratories	140	75	150	175
Goddard Space Flight Center	759	550	950	1 280
Jet Propulsion Laboratory	2 261	1 590	1 700	1 990
Wallops Flight Center	371	375	120	375
Ames Research Center	869	1 030	900	1 250
Dryden Flight Research Center	55	50	37	50
Langley Research Center	700	890	1 000	890
Lewis Research Center	810	750	500	750
Headquarters	<u>5 534</u>	<u>6 000</u>	<u>5 743</u>	<u>7 000</u>
Total	<u>11.980</u>	<u>12.100</u>	<u>11.800</u>	<u>14 600</u>

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1982 ESTIMATES

OFFICE OF SPACE AND TERRESTRIAL APPLICATIONS

TECHNOLOGY UTILIZATION PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

Technology Utilization program objectives focus on the transfer of new knowledge and proven aerospace technology resulting from NASA research and development programs for application and use in the private and public sectors of the United States economy. Important public sector areas include medicine, transportation, environment, urban development and public safety. Specific program objectives are:

- To accelerate and facilitate the application and use of new technology thus shortening the time between generation of advanced aeronautics and space technologies and their infusion into the economy;
- To encourage multiple secondary uses of NASA technology in industry, education and Government where a wide spectrum of technological problems and needs exist;
- To understand more fully the technology transfer process and its impact on the economy, and to manage and optimize the process in a systematic way; and
- To develop applications of NASA's aerospace expertise - its technology, technologists and unique facilities - to priority nonaerospace needs of the Nation.

Aerospace technology is transferred to the public and private sectors of the Nation's economy through a variety of established mechanisms developed and managed under the NASA Technology Utilization program. These mechanisms or project areas include: publications and announcements, industrial applications centers, the Computer Software Management and Information Center (COSMIC), State technology applications centers, applications teams/applications engineering projects, and civil systems projects.

OBJECTIVES AND STATUS:

The NASA Tech Briefs publications continued to generate considerable interest in United States industry last year with nearly 195,000 requests received for additional technical information concerning new technologies announced therein. This activity was slightly higher than the previous year. Recircularization of the Tech Brief mailing list **has** resulted in a net increase of over 12,000 subscribers for the year.

United States industry continued to receive extensive technical information search and assistance service through the NASA-sponsored industrial applications center and State technology applications center network. Similarly, the Computer Software Management and Information Center (COSMIC) maintained an active and aggressive computer program dissemination effort during 1980 with nearly \$500,000 received from industrial users through sales and leases of computer software. Total industrial income for services rendered by these centers (including COSMIC) for 1980 reached \$3.2 million compared to \$2.8 million the previous year. Special emphasis has been placed on improving information delivery services for small business during the past year through local cooperative efforts with SBA-sponsored small business development centers.

Program evaluation activities designed to ensure and increase effectiveness of existing transfer mechanisms were continued during the past year. Such efforts also contribute to the development of experimental projects in technology transfer. As part of program evaluation activities, evidence of technology transfer and industrial utilization is systematically documented and recorded, and selected cases are published and disseminated broadly in the annual "Spinoff" report. The Spinoff 1980 publication achieved widespread acceptance and interest among industry, government, and the general public, and served to create broad awareness of program activities and NASA-sponsored technology transfer services.

Over eighty applications engineering projects for adapting existing aerospace technology to defined needs in the public sector were active last year. Many of these projects are jointly funded by NASA and user agencies such as the Department of Transportation, the Veterans Administration, and the Environmental Protection Agency. The projects include: the portable medical status system developed for the United States Coast Guard; a high reliability water quality monitor for EPA; and an automatic device to aid the deaf by cueing speech being developed in conjunction with Gallaudet College, the National Institute of Health, and the Veterans Administration. Continued effort will be devoted to the problems of the handicapped, with special emphasis placed on developing aids for assisting the elderly.

Current projects in the civil systems program include completion of the advanced ocean technology development platform (AOTDP) for use in evaluating and generating new deep ocean instrumentation and sensors. These new instruments and sensors will be used in scientific investigation and exploration of the ocean floor. Testing of the AOTDP is being conducted with NOAA assistance. A systems design has been accomplished for a sea bed lander as part of the Office of Naval Research/Woods Hole Oceanographic Institute high energy benthic boundary layer experiment (HEBBLE). Development of this sea bed lander will facilitate the exploration of the benthic boundary of the ocean at depths of 4,000 to 6,000 meters. Field tests on an operating water reclamation facility were completed with the Santa Clara Valley District.

CHANGES FROM FY 1981 BUDGET ESTIMATE:

The decrease of \$300,000 in FY 1981 is the result of an overall Congressional reduction in the FY 1981 appropriations request.

BASIS OF FY 1982 \$1

	1980 <u>Actual</u>	1981 <u>Budget</u> <u>Current</u> <u>Estimate</u> <u>Estimate</u> (Thousands of Dollars)		1982 <u>Budget</u> <u>Estimate</u>
<u>Technology Dissemination</u>	3,700	4,100	4,000	4,600

In FY 1982, NASA plans to ensure the continued viability of its effort to meet the Space Act mandate to provide for the widest practicable dissemination of technical information derived from NASA programs. The requested budget will provide for the continuation of NASA Tech Briefs publications and distribution of technical support packages requested by industry. Improvements in information products and services for industrial users of the NASA dissemination center network will also be provided. Selected experimentation in providing information and dissemination and technology transfer services to small business firms and companies in economically depressed rural areas will be continued as a means of developing viable technology transfer models for future implementation. Such activities will be undertaken with increasing cooperation with other Federal agencies such as the Economic Development Administration, the Minority Business Development Administration, and the Small Business Administration.

<u>Technology Applications</u>	4,400	3,800	3,800	5,300
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In FY 1982, NASA plans to continue operation of its six application teams to identify national problems and needs which can be addressed through the application of aerospace technology and capabilities. Additional emphasis will be placed on problem identification and solution in environment, water quality, and national disaster assistance. Multiyear application projects, such as a programmable implantable medication system and a gas analysis instrument for toxic and hazardous waste site survey will continue.

<u>Program Evaluation and Support</u>	1,480	1,600	1,500	1,800
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In FY 1982, NASA will continue to evaluate its technology transfer program through transfer research and impact studies. Special studies will also be undertaken to analyze areas of national need to better define future program thrusts where aerospace technology may have particular applicability. Benefits and economic impacts resulting from NASA technology transfer programs will also be analyzed, documented and assessed to determine what program changes need to be made to increase the effectiveness of existing transfer mechanisms. Publication inquiry support and scientific and technical information (STI) data base support for the NASA dissemination center network will continue at the NASA STI facility .

	1980	1981		1982
	<u>Actual</u>	Budget	Current	Budget
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of Dollars)		
<u>Civil Systems</u>.....	2,400	2,600	2,500	2,900

In FY 1982, NASA plans to continue most of its civil systems projects already initiated with other Federal agencies including, for example, environmental monitoring and control, and agricultural productivity. In addition, the program will allow for a limited degree of flexibility in the selection of new projects that explore innovative applications of aerospace-derived technology to other nonaerospace-oriented disciplines. Specific projects include an automated system to monitor water on a regional basis; remote sensing of the sea floor; and development of an underwater vehicle system to demonstrate application of prototype sonars, sensors and other ocean instruments and data handling subsystems resulting from aerospace technologies.

AERONAUTICS AND
SPACE TECHNOLOGY
PROGRAMS

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1982 ESTIMATES

RESEARCH AND DEVELOPMENT PLAN FOR AERONAUTICS AND SPACE TECHNOLOGY

<u>Programs</u>	<u>1980 Actual</u>	<u>Budget Plan</u>		<u>1982 Budget Estimate</u>
		<u>Budget Estimate</u>	<u>Current Estimate</u>	
		(Thousands of Dollars)		
Aeronautical research and technology.....	308,300	290,300	276,150	323,600
Space research and technology.....	115,586	115,200	110,700	141,000
Energy technology.....	<u>3,000</u>	<u>4,000</u>	<u>3,900</u>	<u>4,400</u>
Total.....	<u>426,886</u>	<u>409,500</u>	<u>390,750</u>	<u>469,000</u>

AERONAUTICAL
RESEARCH AND
TECHNOLOGY

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1982 ESTIMATES

BUDGET SUMMARY

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

AERONAUTICAL RESEARCH AND TECHNOLOGY PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1980 <u>Actual</u>	1981 <u>Budget Estimate</u> (Thousands of Dollars)	1981 <u>Current Estimate</u> (Thousands of Dollars)	1982 <u>Budget Estimate</u>	Page No.
Research and technology base	120.767	131.100	134.300	160.800	RD 9-5
Systems technology programs	<u>187.533</u>	<u>144.200</u>	<u>141.850</u>	<u>162.800</u>	RD 9-23
Total	<u>308.300</u>	<u>275.300</u>	<u>276.150</u>	<u>323.600</u>	
<u>Distribution of Program Amount by Installation:</u>					
Johnson Space Center	745	200	200	100	
Marshall Space Flight Center	725	800	700	800	
Jet Propulsion Laboratory	780	800	800	1,000	
Wallops Flight Center	625	500	600	800	
Ames Research Center	50.590	52.900	54.300	91.000	
Dryden Flight Research Center	12.834	13.200	13.300	17.400	
Langley Research Center	120.096	102.500	101.400	111.000	
Lewis Research Center	117.756	101.100	100.600	97.000	
Headquarters	<u>4.149</u>	<u>3.300</u>	<u>4.250</u>	<u>4.500</u>	
Total	<u>308.300</u>	<u>235.300</u>	<u>276.150</u>	<u>323.600</u>	

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1982 ESTIMATES

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

AERONAUTICAL RESEARCH AND TECHNOLOGY PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objectives of the aeronautics program are to advance aeronautical technology to insure safer, more economical, efficient and environmentally acceptable air transportation systems which are responsive to current and projected national needs; to maintain the strong competitive position of the United States in the international aviation marketplace; and, to support the military in maintaining the superiority of the Nation's military aircraft.

The FY 1982 program supports these objectives by providing for technology advances in all aeronautical disciplines, stressing the technology areas judged to be the most critical by in-house and external assessments, industry, advisory groups, and other users of technology within and outside the Federal government. Emphasis will be placed on improving aircraft energy efficiency and performance, reducing noise and pollution, improving safety and terminal area operations, and advancing long- and short-haul air transportation concepts. A major new activity is the numerical aerodynamic simulator which will permit the United States to maintain a superior computational design capability.

CHANGES FROM FY 1981 BUDGET ESTIMATE:

The increase of \$850,000 in the FY 1981 aeronautics program funding reflects the net effect of several actions. The Congress initially provided an increased appropriation of \$10.25 million for the aeronautics and space technology programs. \$7.25 million of this was allocated to aeronautics, of which \$3 million was applied in the research and technology base for alternative fuels and strategic engine materials research, \$750,000 to general aviation/commuter aircraft propulsion systems technology, and \$3.5 million to high temperature engine core technology (variable cycle). Subsequently, a reduction to the aeronautics program of \$6.4 million was taken as a part of the general Congressional reduction in overall appropriation requests. This reduction was applied to the energy efficient engine program, requiring a rephasing of the funding for that program.

In addition to the programmatic changes mentioned above, the funding levels for several disciplines within the research and technology base have been rebalanced to focus the operational cost of selected Ames Research Center aeronautical facilities by speed regime. The low speed wind tunnels, the high speed wind tunnels, and the fundamental

low speed aircraft operations costs are now, beginning with N 1981, included in the respective high speed and low speed disciplines within the research and technology base. This change will improve the management visibility and budgeting process for the operational costs of these national facilities which support important NASA, DOD, and industry research and development aeronautical research. These changes are addressed more specifically in the appropriate sections of the narratives which follow.

BASIS OF FY 1982 TE

The FY 1982 activities are designed to maintain a strong research and technology base in the technology disciplines of aerodynamics, propulsion, avionics and flight controls, human factors, and materials and structures. Strength in this fundamental research and technology is essential to the future development of new, improved aeronautical products. The aeronautics program also provides focused technology development activity for each of the major classes of aeronautical vehicles.

Transport aircraft technology efforts will continue toward the goal of providing technology in the 1980's capable of major reductions in aircraft fuel requirements. In the energy efficient transport program, work will continue with the major transport airframe contractors to develop and evaluate advanced aerodynamic and active control technologies for derivative and new subsonic transport aircraft. Included are wind tunnel tests of advanced winglets and flight tests of reduced static stability concepts. In the laminar flow control program, emphasis will continue on development of wind tunnel test capability, the evaluation of practical wing surface structures and surface material concepts and preparation for flight tests of wing leading edge laminar flow gloves. In the composite primary aircraft structures program, the remaining medium-sized primary components will enter flight testing, and fatigue and environmental life tests will continue. Subcomponent level testing of key technologies for large structures will be completed. A new follow-on effort, the large composite primary aircraft structures program will be initiated in FY 1982. This effort will move toward the resolution of critical problems in the design and fabrication of very large, thick, highly-loaded graphite component aircraft sections. The terminal configured vehicle program will emphasize flight investigations of improved terminal area operations through the use of advanced avionics systems. Aviation safety efforts will continue progress in the development of cabin materials to reduce crash fire hazards, safe fuels, and the effects of lightning, icing and other severe storm hazards.

In the rotorcraft area, increased emphasis will be applied to rotor system design methodology and large-scale testing, to technology for high speed rotorcraft configuration concepts, and to propulsion systems technology. Major research and technology efforts will continue on rotor aerodynamics and acoustics, rotor/airframe/propulsion system interactions, structural dynamics, advanced composite applications, flight controls and handling qualities, remote site guidance and navigation systems, advanced display and other cockpit systems, human factor pilot machine interfaces, and vibration reduction. Flight research will be continued utilizing the rotor systems research aircraft, the XV-15 tilt rotor research aircraft, and a number of other specially equipped helicopters.

General aviation research and technology will continue to emphasize increased safety, improved utility, and greater energy efficiency. Principal activities will include stall/spin alleviation, drag reduction, engine and propeller improvements, and investigations of avionics systems concepts for safer and simpler single pilot operations. The broad-based VSTOL research and technology will emphasize investigation of propulsion and airframe interference effects in both the low speed VSTOL and high speed cruise/maneuver flight regimes. Flight research will continue using the Quiet Short-Haul Research Aircraft (QSRA) for development of Short Take-Off and Landing (STOL) handling qualities criteria for very high lift conditions.

Supersonic cruise research will continue in the critical discipline areas of aerodynamics, materials and structures, propulsion integration, and systems integration. Emphasis will be placed on improved low speed and high speed aerodynamic performance, advanced titanium structural fabrication techniques, inlet-airframe integration, advanced noise suppression technologies and configuration, and the relationships of range and payload to the economic viability of commercial supersonic flight.

In the area of high-performance aircraft, efforts will continue on two flight activities under the joint NASA/Air Force Advanced Fighter Technology Integration (AFTI) project involving the integrated digital fire/flight control system in the AFTI/F-16 aircraft and the variable camber mission adaptive wing on the AFTI/F-111 aircraft. Flight testing of the Highly Maneuverable Aircraft Technology (HiMAT) concepts will continue using the subscale remotely-piloted research vehicles to establish valid flight characteristics of high risks technology.

In the advanced propulsion systems effort, integrated system tests of the high-spool components assembled in a gas generator core engine will be conducted in the energy efficient engine program. The variable cycle engine technology program will continue to focus on development and demonstration of the critical low-spool technologies unique to a variable cycle propulsion system for future advanced supersonic cruise aircraft. In the advanced turboprop program, effort will focus on the design and fabrication of large-scale propellers and modification of the gas turbine drive system for the ground-based test program.

BASIS OF FY 1982 FUNDING REQUIREMENTS:

RESEARCH AND TECHNOLOGY BASE

	1980	1981		1982	Page
	<u>Actual</u>	Budget	Current	Budget	No.
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>	
		(Thousands of Dollars)			
Aerodynamics research and technology.....	22,587	24,800	23,200	27,200	RD 9-5
Propulsion research and technology.....	26,436	30,900	32,400	36,800	RD 9-7
Materials and structures research and technology.. ■■■■■	16,077	17,800	19,300	23,300	RD 9-9
Avionics and flight control research and technology.. ■■■■	4,804	5,400	5,400	7,100	RD 9-12
Human factors research and technology.. ■■■■■■■■■■■■■■■■■■■■	5,872	6,500	6,500	8,100	RD 9-13
Multidisciplinary research and technology.....	3,760	4,300	4,700	5,900	RD 9-15
General aviation research and technology.. ■■■■■■■■■■■■■■■■■■■■	7,009	7,500	7,500	7,800	RD 9-16
Low speed aircraft research and technology.. ■■■■■■■■■■■■■■■■■■■■	13,884	11,500	11,700	15,200	RD 9-18
High speed aircraft research and technology ■■■■■■■■■■■■■■■■■■■■	13,846	15,300	16,500	20,700	RD 9-19
Transport aircraft research and technology.. ■■■■■■■■■■■■■■■■■■■■	<u>6,492</u>	<u>7,100</u>	<u>7,100</u>	<u>8,700</u>	RD 9-21
Total.....	<u>120,767</u>	<u>131,100</u>	<u>134,300</u>	<u>160,800</u>	
Aerodynamics Research and Technology.. ■■■■■■■■■■■■■■■■■■■■	22,587	24,800	23,200	27,200	

OBJECTIVES AND STATUS:

The objective of the aerodynamics research and technology program is to develop a broad-based technology which will increase our understanding and capability to predict aerodynamic phenomena. This objective is being pursued through an integrated approach involving computational, analytical, and experimental methods to enable aerodynamic optimization of advanced aircraft during the early design stage.

The technology base in computational fluid dynamics continued to expand with an increased capability to predict realistic flow over complex configuration geometries. During the past year, new numerical methods based on vortex

filament tracing were developed to simulate turbulent "bursts" in laminar flows and to investigate three-dimensional turbulent spreading. New methods have been developed for generating solutionadaptive coordinate meshes for use in finite difference solutions of the fluid dynamics equations. A new highly accurate two-dimensional airfoil computer code was developed for analyzing transonic flow Over advanced supercritical airfoils. Work was started to develop and verify three-dimensional transonic wing design methodologies.

A number of accomplishments have been made in the improvement of wind tunnel test techniques and instrumentation development. A rapid and convenient method for measuring skin friction on a wind tunnel model has been developed in which a dual laser beam interferometer measures the change in thickness of a thin oil film which is subjected to a shear stress. Also a long-range, high resolution, laser-doppler anemometer has been developed which can probe the details of turbulent boundary layers and thin wakes in large wind tunnels.

CHANGES FROM FY 1981 BUDGET ESTIMATE:

The decrease of \$1.6 million primarily reflects the change in accounting procedures at Ames Research Center which now captures wind tunnel operational costs under the appropriate high speed and low speed disciplines.

BASIS OF FY 1982 ESTIMATE:

Expanded effort in computational fluid dynamics will continue in FY 1982. Efforts will continue in the development of computational methods to calculate inviscid, laminar and turbulent flows Over aerodynamic surfaces with regions of separations and with emphasis on the transonic speed regime. Increased emphasis will be placed on the development of three-dimensional wind design optimization methods and on incorporating advanced viscous modeling methods into existing three-dimensional inviscid wing analysis codes. Work will continue in the effort to analyze turbulence through the calculation of turbulent flow for first principles. Methods will be developed for the generation of adaptive computational grids about winds and bodies and to integrate their use into steady and unsteady codes.

Multielement airfoil research will include the detailed computational and experimental investigation of the complex trailing edge flows. Laser instrumentation will be utilized to acquire data that will aid in evaluating the applicability of Reynolds stress models for these turbulent wake flows. A more intensive research program in wake vortex hazard alleviation, in cooperation with the Federal Aviation Administration, will focus on aerodynamic design information to minimize wake vortex effects at the source with minimum deleterious effects on performance and noise. In FY 1982, wake vortex research will emphasize fundamental studies in vortex physics which will be applied later to the development of alleviation devices and procedures.

The development of nonintrusive flow measurement methods and instrumentation will be pursued in FY 1982. This includes such areas as holographic interferometry, laser velocimetry and infrared photography. These developments are

designed to provide data otherwise unobtainable, to improve data collection efficiency, and to gather data in a form more amenable to on-line analysis. Work on the integration of theory and experiment will continue, with emphasis concentrated on computer code validation, high incidence forebody vortex flow problems and the use of airframe/propulsion blending techniques to provide a data base for more efficient hypersonic aerodynamic configurations.

Research and technology activity will continue in the development of cryogenic test technology for full-scale Reynolds number simulation. Intensive efforts include model construction, instrumentation development, and pressurized cryogenic wind tunnel control and operation. Emphasis will be given to the development of techniques and devices that will reduce wind tunnel flow interferences. Research on adaptive walls and magnetically suspended models will be included to permit the testing of larger models with greater accuracy and reduced costs.

Exploration of viscous drag reduction schemes for both laminar and turbulent flows will be continued and the most promising will be studied in depth. In particular, surface geometry modifications, such as longitudinal striations, have shown potential for economically important turbulent skin friction reductions.

	<u>1981</u>		<u>1982</u>	
	<u>1980</u>	Budget	Current	Budget
	<u>Actual</u>	<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands	of Dollars)	
Propulsion research and technology.. .. .	26,436	30,900	32,400	36,800

OBJECTIVES AND STATUS:

The objectives of the propulsion research and technology program are to increase aircraft propulsion system efficiency; to improve engine performance; to reduce fuel consumption and dependence on rigid fuel property specifications; to improve the reliability and durability of engine components; to reduce engine noise and exhaust pollution to environmentally acceptable levels which are economically and operationally sound; and to evaluate the potential of advanced new propulsion system concepts. The efforts include research on gas path components, mechanical components, control systems, fuels, computational methods, instrumentation, emissions, and noise. These activities advance the technology that supports propulsion system improvements for all vehicle applications ranging from small, general aviation aircraft, to commercial transports and helicopters, to military aircraft of all types. This program also provides a technology base in noise and emissions for use by the government in establishing aircraft environmental regulations.

The continuing emphasis on internal computational fluid mechanics focusing on computer modeling of the flow fields in compressors and turbines has resulted in the transfer of sophisticated computer codes to industry along with procedures for automatic generation of computational grids. Progress has been made in identifying and characterizing fundamental mechanisms responsible for the generation of fan noise. Investigations of the noise reduction benefits of mixer nozzles, thermoacoustic shields, and shock wave control have been conducted. Turbomachinery components research continues to explore basic fluid mechanics and heat transfer for improving performance and efficiency of fans, compressors, and turbines. Concepts to improve fuel atomization and mixing in premixed, prevaporized combustors have been evaluated to enhance fuel flexibility. In addition, as part of the fuels characterization efforts, gas chromatograph analyses have been able to detect specific chemical property changes that improve the thermal stability of future fuels. In N 1981 additional Congressional funding permits increased alternative aircraft fuels research which will iaentify the aircraft engine and fuel systems affected by use of fuels derived from heavy crude oil, oil shale, and coal. Studies will begin to compare the costs of additional refinement of the fuels as compared to the cost of modifying engine components to accept alternate fuels.

CHANGES FROM FY 1981 BUDGET ESTIMATES:

The increase of \$1.5 million was provided by the Congress for alternative fuels research in FY 1981.

BASIS OF FY 1982 ESTIMATE:

The effort in aircraft alternative fuels technology which resulted from additional congressional funding far FY 1981, will continue at the same level of funding to provide an understanding of critical technologies in aircraft engine and fuel systems which would be affected by the fuels derived from heavy crude oil, oil shale, and coal. Refinery tradeoff studies will also be continued and the data base in fuels characterization will be expanded.

In FY 1982, noise reduction research will explore fundamental investigations to identify and characterize elemental noise-generating mechanisms associated with various engine sources. Analytical models of fan and turboprop noise generation will be developed and techniques for jet noise reduction through use of mixers, thermoacoustic shields, and shock wave control will continue with emphasis on interrelationships between aerodynamic performance and noise.

Research on inlets and nozzles will concentrate on development and verification of analytical techniques which will incorporate localized internal flow phenomena. New three-dimensional computer codes will be used to investigate new inlet concepts which could result in superior aircraft performance.

Research in computational fluid mechanics will continue the development of advanced computer codes which model the internal flow performance in advanced gas turbine engines. FY 1982 code development will emphasize inviscid solutions for transonic flow and interactive parabolic matching techniques for three-dimensional viscous flows.

Improving performance and efficiency of commercial and military turbofan engines will require higher operating temperatures and pressures. Research in fans and compressors in N 1982 will focus on unsteady aerodynamics, stall recovery, scaling, and stage-matching techniques. Turbine research will focus on fundamental heat transfer and fluid mechanics experiments with emphasis on flow transition, separation, mixing, and on rotational effects.

In N 1982, instrumentation research will concentrate on measurement techniques in higher pressure and temperature environments. Identification and incorporation of advanced materials into instrumentation and application of non-intrusive techniques for gas path flow measurement and visualization will be emphasized.

Advanced propulsion research will continue to pursue activities to gain an understanding of the fundamental processes associated with hypersonic propulsion. Computational methods are being developed and validated to predict turbulent combustor flow characteristics. A second generation supersonic combustion ramjet has been designed and will be fabricated and initially tested in FY 1982.

Power transfer research will continue evolutionary technology improvements in gears, **seals**, bearings, and lubricants for advanced gas turbine and power transmission system applications. Increasing emphasis will be placed on understanding the basic lubrication and wear mechanisms associated with high speed bearing elements.

	1980 <u>Actual</u>	1981 <u>Budget</u> <u>Estimate</u> (Thousands of Dollars)	1981 <u>Current</u> <u>Estimate</u> (Thousands of Dollars)	1982 <u>Budget</u> <u>Estimate</u>
Materials and structures research and technology.. .. .	16,077	17,800	19,300	23,300

OBJECTIVES AND STATUS:

The objectives of the materials and structures research and technology program are to develop and characterize advanced metallic, ceramic, polymer and composite materials; to develop structural concepts and design methods to permit the use of advanced materials in aircraft; to develop analytical and experimental methods for determining the behavior of aircraft structures in flight environments; and to generate research data to promote improvements in performance, safety, durability, and economy. Areas of emphasis include high temperature engine and airframe materials and structural concepts; composite materials application, life prediction, thermal and dynamic response, and aeroelasticity; and more accurate and efficient integrated design methods for airframes and engines.

Improvements are being made in the properties of several metal alloys, ceramics, and composites that promise increased performance, lower cost, and efficiency in gas turbines and aircraft structures including research resulting from additional Congressional funding in FY 1981 to reduce the use of strategic cobalt, columbium, and tantalum in gas turbines. Advances are also being made in the capability to predict the life of composites and metals which will improve the reliability of aeronautical systems. In composite structural applications, concepts for improving damage tolerance by means of buffer strips, bonded stringers, and translaminar stitching have been validated, and efforts to develop tougher resins have resulted in the identification and initial assessment of promising compositions, such as rubber-toughened epoxy, novel one-phase thermosets, and modified thermoplastics.

Data generated in FY 1980 during flight evaluation of an active flutter suppression system on a research wing will be critically assessed and correlated with wind tunnel data analytical predictions prior to resumption of the flight program in the latter part of FY 1981. The "decoupler pylon" concept for military aircraft stores flutter alleviation has been validated in wind tunnel tests and plans for follow-on flight evaluation are being formulated.

FROM FY 1981 BUDGET ESTIMATE

The increase of \$1.5 million reflects additional funds provided by Congress for strategic engine materials research in FY 1981.

BASIS OF FY 1982 ESTIMATE:

Research on high temperature materials will continue to emphasize improving the strength and service life of gas turbine materials. During N 1982, materials processing and design technology will continue to be developed for an oxide dispersion alloy and a tungsten fiber reinforced superalloy which have potential for hollow turbine blade applications. A test program will be carried out on a low cost, dual property disk alloy having improved mechanical properties. Basic research on the mechanisms of corrosion and oxidation of turbine alloys will continue. Ceramic materials will continue to be developed, with emphasis on improving high temperature strength and impact resistance. In FY 1981, Congress provided additional funds to find ways to reduce our reliance on unstable foreign sources of materials which are currently essential to the fabrication of gas turbine engines. In FY 1982, activity to reduce this strategic material usage in gas turbine alloys by alloy substitution, improved processing, coating development, and research in intermetallics as replacements will continue at the FY 1981 funding level. Research will continue on the fatigue and fracture behavior of metallic, ceramic, and composite materials in both benign and active environments. Research will be accelerated to extend existing life prediction techniques and analyses into the viscoelastic regime. Studies will continue on the mechanism of hydrogen embrittlement of steels with the objective of developing hydrogen-resistant alloys. To predict service durability of composites, a damage growth law will be developed. Research on composites will continue to be emphasized in the development of stiff, lightweight, structural materials. New opportunities for increased weight savings using advanced powder metallurgy aluminum alloys will be explored. In FY 1982, studies will

continue on low cost fabrication processes and applications of composites in fixed-wing aircraft. Study emphasis will be placed on methods for evaluating and increasing the durability and damage tolerance of composite components. Exploratory research will be continued on new resins that will permit the development of tougher, impact resistant, more processable composites. The fabrication and evaluation of advanced composites for high performance engine blades will continue in FY 1982. A data base and fundamental understanding will continue to be developed for the combustion characteristics and the thermochemical, thermophysical, and photochemical properties of new and advanced polymers.

In loads, dynamics, and aeroelastic research, the N 1982 program will continue to develop and validate improved unsteady aerodynamics prediction methods, with major emphasis on the transonic speed range, based on both frequency and time domain computational techniques. Aeroelastic analysis tools will be developed for application to wings and to turbine engine fans, compressors and turbine blades, and validated by means of experimental data from wind tunnels, spin rigs, cascade rigs, and flight tests. Concepts for active and passive control of aeroelastic behavior will be developed and validated. Methods for the prediction and control of structure-borne aircraft interior noise will also be developed. Transport crash dynamics studies will continue beyond the survivable crash scenario definitions being pursued in FY 1981 to develop modeling techniques for crash response prediction and to define component and scaled model tests for concepts and prediction methods validation.

Development of integrated analysis/synthesis methods in FY 1982 will focus on methods for simultaneous optimization of the structural and aerodynamic configurations and performance attributes of airframes that incorporate new technologies such as active controls and advanced composite materials. An ongoing program to develop a prototype finite element computational device using microprocessor components will be continued toward hardware demonstration in N 1982.

High temperature structures research will continue to develop nonlinear analysis methods for predicting the response of airframe components to transient thermal loads, and for predicting the useful structural life of turbine engine hot section components. Concepts for improving the thermostructural efficiency of such structures will continue to be developed and validated.

		<u>1981</u>		<u>1982</u>
	<u>1980</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
	<u>Actual</u>	<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of Dollars)		
Avionics and flight control research and technology..	4,804	5,400	5,400	7,100

VES AND STATUS:

The objective of the avionics and controls research and technology program is to support the development of advanced electronics for applications to both civil and military aviation. Major efforts are directed toward enhancing utility, safety and efficiency, while reducing costs, in the areas of navigation/guidance, crew station technology, aircraft controls, and systems integration techniques.

A spectrum of navigation is being investigated for the development of concepts for use in improving traffic flow in the national airspace system. Cooperative tests with the Department of Transportation and the State of Vermont are being completed to evaluate the use of LORAN-C for aircraft operations in mountainous areas. Based on preliminary flight test results, the system's performance exceeded FAA requirements for navigational accuracy in these remote areas. Studies and laboratory simulations are being conducted to establish the minimum requirements for a satellite-based navigation system for a broad spectrum of civil users and appropriate antenna designs are being evaluated. Development of advanced weather radar techniques is continuing for detecting enroute turbulence as well as wind-shear near airports. In the crew station technology area, "hot bench" and lightning laboratory evaluations are being conducted on promising flat panel display media for application to advanced crew station designs.

The current tasks in controls and systems integration technology are focused on the development of ultrahigh reliable architecture and techniques for application to future aircraft systems. A control system technique involving a special filter design was recently demonstrated and proved highly successful in enhancing a pilot's ability to control an aircraft under high stress landing conditions. This technique is being applied to the Shuttle and will form the basis for application to other vehicles. Laboratory analyses of fault tolerant computer designs are being conducted and methods of determining their susceptibility to lightning-induced transients are under development. A conceptual design of a highly reliable flight control system based on the use of microprocessors is being completed and the development of a preliminary detailed design is being initiated. Methods for the integration of flight controls, propulsion and other system functions are being developed for the formulation of a fully integrated system design including logical processes for decision making, resource management, and fault detection and resolution. Coupled to this effort is the development of system reliability assessment tools.

BASIS FOR FY 1982 ESTIMATES:

Indepth assessment of the avionics and controls research and technology program indicates promising opportunities to improve aircraft efficiency, extend operational capability, and improve safety through the application of advanced technology. While there has been a proliferation of control systems, computers and electronic devices to improve aircraft performance, increased emphasis **is** needed in the functional and physical integration of controls and avionics hardware and software to provide efficient designs that will improve the operational cost and overall system **performances**. Closely coupled is the requirement for highly reliable architecture to hasten the technology transfer and implementation of these innovative architectures. In addition, a better understanding of the effects of lightning strikes on electronic systems is necessary to assure digital system compatibility and to provide circuit "hardening" protective techniques as required. The FY 1982 program will focus on these technology needs.

	1980 <u>Actual</u>	1981 <u>Budget</u> <u>Estimate</u> (Thousands of Dollars)	1981 <u>Current</u> <u>Estimate</u>	1982 <u>Budget</u> <u>Estimate</u>
Human factors research and technology.. .. .	5,872	6,500	6,500	8,100

OBJECTIVES AND STATUS:

The objective of the human factors research and technology program is to provide a research and technology base for solutions to the human factors problems which influence the growth, efficiency, and safety of air transportation. The program has three areas of emphasis: flight management, flight simulation technology, and human response to noise.

In the area of flight management, circadian desynchronization research **has** transitioned from the definitional to the operational stage. Activity is underway to distill available practical knowledge from the literature and disseminate it to the community and ascertain actual crew rest and dietary patterns. These activities will provide a data base for an expanded research program in FY 1982 including laboratory and simulation investigations. A joint NASA/FAA Cockpit Display of Traffic Information (CDTI) program plan **has** been signed and development of a generic candidate display format has been completed. Simulation evaluations of pilots' capability to perform appropriate tasks while monitoring the display are underway. The effects of sensor noise, size of display and various candidate procedures are also being studied. NASA's portion of the joint NASA/FAA Head Up Display (HUD) research program will be completed in FY 1981. Full-mission simulation evaluations of air carrier pilots' ability to use HUD as a primary landing aid have been completed and findings were communicated to the aviation community. The FAA will now perform flight tests of the NASA developed HUD display concept. The human factors guidelines for Head Up Displays will serve as a primary input to the

FAA in the design of its HUD certification procedures as well as to HUD manufacturers, the aircraft manufacturers, and the airlines.

The simulation technology program emphasis includes validation of a model of motion/visual cue interaction which holds the promise of providing the basis for significant increases in simulation fidelity at reduced cost; and, investigation of the feasibility of replacing all aircraft time with simulator time in the transition training of airline pilots.

Major thrusts in research on human response to aircraft noise are: (1) a joint NASA/FAA community survey of annoyance at flyovers of various types of aircraft at different times of the day; and, (2) a joint NASA/EPA investigation of the costs and benefits of various alternatives for alleviating the impact of aircraft noise on communities.

BASIS OF FY 1982 ESTIMATE:

In N 1982, the flight management research program will emphasize CDTI, aircrew performance and advanced crew station human factors. The joint NASA/FAA CDTI program will move from Phase I, in which studies were limited to single simulator investigations of the "pilot as monitor" concept, to Phase II which will encompass multiple simulator studies of pilot ability to use the CDTI to assume certain air traffic control functions. A primary emphasis of the work will be an investigation of the interactive effects of CDTI with other planned innovations such as collision avoidance systems and automatic traffic advisory and resolution service.

In the area of aircraft performance, efforts in crew resource management and circadian desynchronosis will increase the knowledge of the causes of human error in aviation, especially as it regards decision making and problem solving under stress. Preliminary definition work on crew resource management in FY 1980 and line oriented flight training in FY 1981 will evolve into laboratory and simulation investigations. Increased emphasis will be placed on the generation of crew workload and performance measures. Circadian desynchronosis work will also focus on laboratory investigations and appropriate field studies of the effects of the dietary and rest patterns of airline crews. These efforts are designed to assess the range and extent of circadian desynchronosis effects, develop methods of minimizing those effects, and determine crew tolerance limits.

Advanced crew station human factors efforts will emphasize the generation of guidelines for aircraft systems and operations tolerant to human error based on earlier exploratory work defining the proper role of automation in the cockpit. Candidate automation guidelines will be evaluated under controlled conditions in high-fidelity, full-workload simulators with integrated air traffic control simulation. Conditions which led to accidents will be recreated through simulation, and the effects of various degrees and types of automation will be studied. A corollary of this work will be an investigation of the roles of aircraft crews under conditions of increased automation.

Flight simulation research in FY 1982 will prepare the way for the multicab simulation facilities being developed at Ames Research Center (the Man-Vehicle Systems Research Facility, MVSRF) and at Langley Research Center (the Mission Oriented Terminal Area Simulation, MOTAS). Research will address the development of research methodologies which can take maximum advantage of the new multicab capability. In addition, our ongoing development of pilot/simulator models to explore new technologies for increasing simulation fidelity will continue.

Human response to noise research in FY 1982 will concentrate on two needs. The first is the development of schemes to minimize the noise impact around commercial jet airports through improved operating procedures. This will be accomplished through the refinement of the airport noise level and annoyance model. The second area will be a concentrated effort to better understand the effects of noise on people in airport communities through direct measurement of noise from aircraft flyovers together with simultaneous subjective measurements of annoyance.

	1980	1981		1982
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of Dollars)		
Multidisciplinary research.....	3,760	4,300	4,700	5,900

OBJECTIVES AND STATUS:

The objective of the multidisciplinary research program is to conduct novel, long-range, high risk basic research investigations in engineering and physical sciences related to aeronautics. This research is conducted principally at universities through: (1) the fund for independent research, which supports unsolicited proposals and proposals received in response to announcements of research opportunities in specific areas, such as, boundary layer-shock wave interactions, turbulent structure in a free shear layer, mean rate of energy transfer in turbulence, investigation of lasers for turbulence measurement, vaporization of droplets, flow over a cavity, etc.; (2) the graduate program in aeronautics, which supports graduate studies where the thesis research is performed, at least in part, at a NASA research center using NASA facilities; (3) the post-baccalaureate program, which supports graduate study at the masters level including significant research experience at a NASA research center; (4) the computational fluid dynamics (CFD) training program initiated in FY 1980, which supports the establishment of balanced CFD training programs in selected universities; and, (5) the base level support for the Joint Institute for Advancement of Flight Sciences (JIAFS), the George Washington University program at the Langley Research Center.

CHANGES FROM FY 1981 BUDGET ESTIMATE:

The increase of \$400,000 reflects the transfer of additional funding for the post-baccalaureate program from the aeronautical systems studies program element. This high priority program involves masters-level graduate students in the performance of research at NASA research centers, and thereby promotes a source of new researchers in the NASA program activities.

BASIS OF FY 1982 ESTIMATE:

The fund for independent research will continue at the ongoing level of support in basic research at universities. The previously mentioned programs supporting graduate education in aeronautics will be increased substantially to encourage more engineers to enter the aeronautics profession by offering greater opportunities for them to train with NASA senior research staff members at the research centers.

	1980 <u>Actual</u>	1981 <u>Budget</u> <u>Estimate</u> (Thousands of Dollars)	1981 Current <u>Estimate</u>	1982 <u>Budget</u> <u>Estimate</u>
General aviation research and technology.. .. .	7,009	7,500	7,500	7,800

OBJECTIVES AND STATUS:

The objective of the general aviation research and technology program is to provide the technology base for achieving important improvements in general aviation aircraft safety, utility, and energy efficiency. Multidisciplinary in nature, the program encompasses aerodynamics (performance, stability, and control), materials and structures, propulsion and fuels, avionics and human factors.

Stall/spin program objectives include developing accurate analytical techniques for predicting aircraft stall/spin characteristics, and reliable design methods for achieving desired stall/spin characteristics in new aircraft. Research continued on stall/spin behavior of light single engine aircraft, with emphasis on the influence of wing leading edge modifications on stalls and unrecoverable spin modes. A stall/spin workshop attended by industry, university, and government experts was held. Drag reduction research included cooling drag of air-cooled engines and studies of natural laminar flow airfoils suitable for general aviation. Preparations were made for instrumented flight tests on an early natural laminar flow airfoil wing design for experimental correlation with recent analytical methods, and to prepare for

future improved designs. Propulsion research included low speed propellers and intermittent combustion engines. Flight tests confirmed new low noise design methods for propellers. Laboratory tests confirmed the feasibility of design modifications to certain existing spark-ignited reciprocating aircraft engines for near-term improvements in fuel consumption, and preparations for flight tests were completed. A computer code for analyzing intermittent combustion and thermodynamic processes was completed. Studies of advanced aircraft engines, both spark-ignited and diesel, indicated the feasibility of 30 to 50 percent improvements in fuel efficiency over today's engines, together with multifuel capabilities, low weights, and low frontal areas. In structures research, tests of energy absorbing load-limiting aircraft seat concepts were completed and investigations begun on the dynamic load-limiting characteristics of selected fuselage subfloor structures. Studies to define composite structures materials and methods best suited for light aircraft are also being undertaken. In the area of operations and safety, an automated pilot advisory system suitable for general aviation airports not equipped with control towers was successfully demonstrated in public operational tests at the Manassas, Virginia airport. Other avionics and human factors research continued on instrumentation, displays, pilot functions, flight operations and procedures aimed at improved general aviation operational safety and utility, particularly under instrument flight rule conditions. Research on the fundamentals of aerial application of agricultural materials included wind tunnel and flight evaluations of wake modification devices (winglets) to improve swath uniformity and control.

BASIS FOR FY 1982 ESTIMATE:

Stall/spin research will be extended to twin engine aircraft and unconventional configurations, and additional effort applied towards basic analytical procedures and design methods. A wing glove embodying a new natural laminar flow airfoil will be built and flight tested to investigate three-dimensional effects and actual flight environment influences. Other drag reduction research will include surface interaction/interference drag and propulsion installation drag. In structures, further development of crash energy absorbing, load-limiting structural analysis and design methods will proceed, and a research program for composite structures tailored to the technical and economic requirements of light aircraft will be developed. Emphasis will be placed on propulsion research, both propellers and engines, with increased levels of effort which will subsequently culminate in experimental verification of major improvements. Propeller objectives for both general aviation and commuter aircraft include noise reduction, aerodynamic efficiency, and composites for lower weight and greater safety. Engine objectives for both advanced intermittent combustion concepts and small turboprop engines include increased fuel economy and affordability, along with multifuel capabilities and other desired characteristics. Research on suitable general aviation avionics improvements and human factors will continue, primarily addressing issues related to single pilot operations. Research will also continue in the area of aerodynamically integrated distribution systems for aerial applications to improve application uniformity, accuracy and productivity, and to reduce drift.

	1980	1981		1982
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of Dollars)		
Low speed aircraft research and technology.. .. .	13,884	11,500	11,700	15,200

OBJECTIVES AND STATUS:

The objectives of the low speed aircraft research and technology program are to provide a technology base in the areas of: (1) rotorcraft structures and dynamics, aerodynamics and flight dynamics, avionics and controls, and man-system integration; (2) hybrid airship configuration performance, dynamics and controls; and (3) Vertical and Short Take-Off and Landing (V/STOL) aircraft propulsion, aerodynamics, and flight dynamics.

During the past year, the performance, dynamics, and control and acoustic characteristics of several large-scale rotor systems were determined through tests in the 40x80 foot wind tunnel. These systems included an advanced aerodynamic research rotor, a bearingless main rotor, and a coaxial advancing-blade concept rotor. Improved computational and experimental methods have been developed for determining rotor airfoils that are optimized for selected rotorcraft design operating conditions. Analytic, ground-based simulator, and flight research is continuing on improved rotorcraft control and flight systems to reduce pilot workload, to provide certification criteria, and to enhance mission capability. Very **small**, air-driven motors are being acquired which can accurately simulate the inlet and nozzle propulsion flows for small-scale wind tunnel models of V/STOL aircraft models in cruise/maneuver flight. Progress continues on computational methods for predicting V/STOL airframe and propulsion flows, on experimental equipment for scale model investigations of V/STOL propulsion systems, and on simulator evaluation of control and flight systems for improved V/STOL flying qualities and mission capabilities.

2) FROM FY 1981 BUDGET ESTIMATES

The increase of \$200,000 reflects primarily the rebalancing of the research and technology base to budget the total use of the low speed facilities at the Ames Research Center in the low speed research and technology base discipline beginning in FY 1981.

BASIS OF FY 1982 ESTIMATES:

Rotorcraft research in FY 1982 will include analytical and wind tunnel tests of small-and large-scale models to improve design prediction capability of rotorcraft performance, loads, vibration, and aeroelastic stability. The use of higher harmonic controls to reduce vibration will be evaluated in flight. Research on interactional aerodynamics and

dynamic load predictions will be expanded. Greater emphasis will be placed on acquiring practical data on rotor noise, and on verifying noise prediction methods. Development will be initiated of a total automatic flight and control system and an estimating code for a UH-1H research helicopter with fault tolerant sensing and computing capability. Research activities will continue in FY 1982 to develop a helicopter human factors data base with emphasis on advanced pilot display/control interface techniques including automatic speech recognition, speech synthesis, and visual/auditory/tactile displays. A cooperative program will be continued with the United States Coast Guard to develop the configuration aerodynamics, control, and structural dynamics technology for hybrid airship concepts that hold promise for potential patrol and surveillance applications.

In the V/STOL area in FY 1982, compact propulsion simulators developed in the past two years will be incorporated into a complex small-scale model of high performance V/STOL configuration. This will support research on propulsion system/airframe interactions in high speed cruise/maneuver flight regimes through tests in transonic and high subsonic wind tunnels. Work will continue on computational methods and supporting experimental techniques and measurements to develop a capability to predict airframe/propulsion and ground flow interactions in a manner suitable for design evaluation purposes. A new V/STOL propulsion fan drive will be put into operation in the Lewis Research Center 9 x 15 foot subsonic wind tunnel for research on V/STOL inlets, vectorable exhaust nozzels and fast response thrust modulation.

	1980 <u>Actual</u>	1981		1982
		<u>Budget</u> <u>Estimate</u> (Thousands of Dollars)	<u>Current</u> <u>Estimate</u>	<u>Budget</u> <u>Estimate</u>
High speed aircraft research and technology.. .. .	13,846	15,300	16,500	20,700

OBJECTIVES AND STATUS:

The objective of the high speed aircraft research and technology program is to generate technology advancements needed both to achieve safe, reliable, and economical high speed civil aircraft and to establish and maintain technological superiority in military high speed vehicles and systems.

In the area of flight dynamics, emphasis continues on the important high angle-of-attack and stall/spin flight regimes. Extensive analyses, simulations, wind tunnel and free-flight model tests were performed during the last year in cooperation with the military services on new fighter/attack aircraft and advanced design concepts, including a supersonic cruise and maneuver configuration. In the area of combat vehicle aerodynamics, experimental data were obtained for three different high speed aircraft designs with vortex flaps, and significant progress was made in the development of a theoretical understanding of leading edge vortex effects. During the last year, wind tunnel and

electromagnetic anechoic chamber tests have been used to evolve an efficient and stealthy configuration for a supersonic cruise missile having a high lift-to-drag ratio, good aerodynamic stability and control characteristics, and a low radar cross section. Stealth considerations have also been considered for fighter aircraft exhaust nozzles as part of the propulsion integration effort during the last year.

CHANGES FROM FY 1981 BUDGET ESTIMATES:

The increase of \$1.2 million reflects a change in the accounting procedure at the Ames Research Center. The class of facilities categorized as high speed wind tunnels are funded in this budget category beginning in FY 1981.

BASIS OF FY 1982 ESTIMATE:

In FY 1982, the flight dynamics effort will extend the study of fighter configurations to include three aerodynamic lifting surfaces to establish a firm understanding of the effects of aerodynamic factors and flight control system characteristics on high angle-of-attack maneuverability and stall behavior. Wind tunnel experimental investigations will be initiated on the use of power devices such as thrust vectoring for high angle-of-attack dynamic control.

The aerodynamics and propulsion activities will concentrate on three areas -- fighter configuration aerodynamics, two-dimensional nozzle integration, and missile aerodynamics. Experimental data will be obtained and improved analytical methods will be developed to establish a design methodology for the nonlinear aerodynamic performance and stability and control characteristics of new fighter concepts. Two-dimensional nozzle propulsion integration efforts will concentrate on performance and stealth trades. The blended wing-body configuration concept developed in the supersonic cruise research program will be applied to missiles with assessments made of potential performance improvements.

In FY 1982, as part of the interagency and industrial assistance and testing effort, computational facilities, simulators and wind tunnels will be used to provide support to other government agencies and to the aircraft/missile industry for a broad range of aircraft and missile developments.

The remotely-piloted research aircraft technology activities in FY 1982 will refine new and improved concepts for ground controller management of flight operations for high speed testing and recovery of remotely piloted research vehicles.

Flight experiments support activities, including chase operations, airspeed calibration pacer flights and remotely-piloted research vehicle air drops, will be conducted providing support to a broad base of high speed research vehicles.

High speed wind tunnel operations in FY 1982 will generate experimental test data of a generic nature for a wide variety of vehicle configurations to support research and technology programs.

In FY 1982, the high speed aircraft controls technology activities will concentrate on determining the best, fully integrated, digital ~~airframe/propulsion~~ control system architecture for the next generation of high speed aircraft. The efforts will be directed toward future civil and military high speed aircraft in which integration of the airframe control functions and propulsion control functions will be essential to the aircraft concept.

The hypersonic vehicle technology effort in FY 1982 will focus on the key technical problem areas of hypersonic airbreathing cruise aircraft and missiles, including aerodynamic characteristics, inlet and nozzle integration with the airframe, propulsion performance and high temperature structures.

	1980	1981		1982
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of Dollars)		
Transport aircraft research and technology.. ■■■■■■■■■■	6,492	7,100	7,100	8,700

OBJECTIVES AND STATUS:

The objective of the transport aircraft research and technology program is to provide a broad base of safety-oriented technology for understanding and dealing with aeronautical safety hazards and their consequences, and improving criteria for design of aircraft systems and operating techniques leading to reduction in accidents, **loss** of life and injuries, and **loss** of equipment. The safety research program **has** been organized into three major categories: aviation meteorology, aviation operations safety technology, and aircraft systems operating efficiency improvement.

In meteorology research, significant progress continues to be made in characterizing lightning and turbulence associated with severe storms. A specially hardened and highly instrumented F-106 research airplane safely penetrated thunderstorms to obtain measurements of lightning and the production of gases, winds and turbulence. The test results will provide a basis for establishing design and lightning protection criteria for advanced digital avionic systems, as well as aircraft operating procedures, and for the prediction and avoidance of severe storms. Research continues in evolving a computer code for the prediction of severe storms. Three tornado case studies have validated the design approach. In-flight remote sensing of hazardous clear air turbulence and associated ozone will continue based on microwave radiometer technology. The expanded icing research and technology requirements were developed from a cross section of the aviation community. Analytical methods were initiated for predicting ice accumulation and associated aerodynamic penalties. Ice protection systems for modern airfoils were evaluated using fluids, icephobics and advanced pneumatic boots. Flight research **was** initiated to measure the aircraft wing ~~span-wise~~ structural loadings due to atmospheric turbulence.

Advances were made to increase occupant survivability in post-crash fires by breaking the fire chain through the use of a safety fuel, antimisting kerosene (AMK), and fire resistant aircraft seat cushions, interior wall panels and fuselage windows. Advanced technology materials continue to be demonstrated in full scale fuselage fire tests and evaluations of AMK in jet engines.

The in-flight airframe loads measurement program which utilizes digital data from wide-body aircraft continues and was expanded to cover ground operations to define items of the actual operating conditions experiences of landing gear system components. Advanced technology landing gear, antiskid brake systems and tires will evolve from this knowledge.

In landing gear systems technology, analytical tire modeling, tire wear testing, and a taxing tire thermal study were completed. Prediction of aircraft stopping performance on typical runway surfaces based on ground vehicles measurements was completed. Work has been initiated on tire and wheel failures and their consequences on aircraft control. Based on initial successes of active control landing gear research to reduce structural loading and improve ride qualities, cooperative research was initiated with the military to test this concept on fighter aircraft. Evaluations of current antiskid braking systems and runway slipperiness studies were completed and incorporated in the aircraft ground handling simulator.

BASIS FOR FY 1982 ESTIMATE:

FY 1982 research in meteorology hazards to aviation will continue using two flight research aircraft to characterize severe storms and the effects of lightning and turbulence on future aircraft systems design and operations. Dissipation of warm fog using the charged particle concept will be evaluated in the field. Icing research will include development and evaluation of improved icing sensors, scaling laws and study of modern airfoils under icing conditions. Improvements in wind tunnel productivity for icing experiments are planned using improved aerodynamic measurement devices.

Aircraft fireworthiness research to improve occupant survivability will conclude the evaluation of advanced aircraft interior materials and cabin windows under full-scale fire testing. The design requirements for a fire resistant materials data bank will be completed. Successes in engine component compatibility with AMK will lead to long-term and complete engine performance evaluations using AMK. Alternate AMK additives will be developed and evaluated that would further reduce engine and fuel system modifications needed for practical fleetwide implementation.

Research in aircraft landing systems will continue studies of the effects of tire failures on aircraft controllability. Long-term studies of tire behavior and optimized design will begin using inputs from the tire thermal, friction and wear studies that will have been completed. Development of advanced elastomers for tire carcasses will continue based on tire tread experience. An in-service evaluation is planned. Development of the ground handling simulator will continue based on completed research in antiskid and brake systems and aircraft performance on slippery runways. Advanced antiskid systems development will begin.

BASIS OF FUNDING REQUIREMENTS:**SYSTEMS TECHNOLOGY PROGRAMS**

	1980	1981		1982	Page
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>	No <u> </u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>	
		(Thousands of Dollars)			
Materials and structures systems technology	5.553	9.600	9.600	9.800	RD 9-24
Propulsion systems technology	6.700	4.900	4.900	3.800	RD 9-26
Avionics and flight control systems technology	2.206	1.550	1.200	1.300	RD 9-27
Aerodynamic vehicle systems technology	189	---	---	---	---
Aeronautical systems studies	4.134	3.600	3.200	3.800	RD 9-28
General aviation systems technology	712	100	1.050	---	RD 9-29
Low speed systems technology	23.175	23.450	24.300	38.500	RD 9-30
High speed systems technology	14.695	16.800	16.700	19.400	RD 9-33
Transport aircraft systems technology	57.891	33.500	33.100	31.400	RD 9-35
Advanced propulsion systems technology	72.278	50.700	47.800	38.800	RD 9-37
Numerical aerodynamic simulator	---	---	---	16.000	RD 9-39
Total	<u>187,533</u>	<u>144.200</u>	<u>141.850</u>	<u>162.800</u>	

	1980	1981		1982
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of Dollars)		
Materials and structures systems technology.. .. .	5,553	9,600	9,600	9,800

OBJECTIVES AND STATUS:

The objective of the materials and structures systems technology program is to concentrate research efforts in the structures and materials technology areas which have high prospects for near-term application in the design of aircraft and engine systems.

The materials for advanced turbine engines effort involves the identification of promising concepts and related high temperature materials now in advanced laboratory stages for transition into actual engine tests for the development of process and engineering data. In FY 1981 effort, an advanced directionally solidified turbine blade alloy was engine tested, single crystal turbine blades were fabricated, and an advanced abradable tip seal and a new high temperature powder metallurgy disk alloy were engine tested.

The aeroelasticity of turbine engines technology activity is a joint Air Force/NASA effort to improve the understanding and prediction capability for aeroelastic instability and response phenomena in turbine fan stages. Analytical methods developed for predicting subsonic and supersonic flutter and pressure rig data generated for two experimental rotors are being correlated.

The integrated program for aerospace vehicle design will achieve a major program milestone in FY 1981 with the release of an engineering data management software system for evaluation by industry and NASA. An experimental pilot system released early in the year is already being used by several aircraft companies and at NASA's Langley Research Center.

The objective of the turbine engine hot section technology activity is to provide the technology base for improved life assurance and life management of the hot section components of advanced turbine aircraft engines. Major tasks are to develop analytical and design methods which will enhance hot section component durability. These methods will provide environmental definition, thermal and mechanical load prediction, structural analysis, and local response and failure mode characterization. Combined use of these methods will increase the capability for hot section component life prediction. This systems technology program is an outgrowth of past basic research and fundamental technology development, such as combustor and turbine blade durability analyses and laboratory experiments.

BASIS FOR FY 1982 ESTIMATE:

During N 1982, the emphasis in the materials for advanced turbine engines effort will be on demonstrating the engine test performance of single crystal turbine blades, an advanced directionally solidified turbine blade, and a high temperature burner liner. The goal is to reduce the specific fuel consumption in engines by 1.5 percent using these materials.

The N 1982 aeroelasticity of turbine engines effort will continue the correlation between analytical predictions and experimental data. This will include transonic flutter prediction methods and cascade tunnel data being generated in FY 1981. Some effort will be devoted to research of forced response phenomena.

The integrated program for aerospace vehicle design effort in N 1982 will focus on an evaluation of the initial software release in order to identify enhancements necessary to improve performance and usefulness to potential users. Ongoing efforts will be continued to identify and advocate developmental efforts necessary to establish proper interfaces with the Air Force's integrated computer aided manufacturing program.

During N 1982, emphasis in the hot section technology activity will be on defining the turbine environment through the conduct of "benchmark" component simulation tests and the development of associated instrumentation. In these tests, relatively simple hardware elements containing stress concentrations will be subjected to high temperature, low cycle, creep-fatigue conditions. Simultaneously, analytical solutions for stresses and strains of the stress discontinuity will be obtained from available three-dimensional, finite element, elastoplastic computer programs. Direct measurements of the local strains in the high temperature testing activity will provide the desired check on the ability of the structural analysis to accurately calculate the stress/strain conditions and provide insight for needed improvements. In addition to the "benchmark" tests, a broad range of component simulation tests will be designed and conducted for defining static and cyclic thermal and mechanical loadings, the materials and structural responses, as well as failure locations, modes, and lifetimes for combustor liners, vanes and blades, disks, gas path seals and static structure. These simulations will provide documented test conditions and durability data for use in model formulation and subsequent predictive methods evaluation.

	1980	1981		1982
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of Dollars)		
Propulsion systems technology.	6,700	4,900	4,900	3,800

The objective of the aeronautical propulsion systems technology program is to provide focused, systems oriented activity to achieve improved performance, reduce environmental impact, lower fuel consumption, and improve durability and reliability, and fuel flexibility for advanced propulsion systems for application to a broad range of vehicle systems through the integration of advanced components.

The helicopter transmission systems technology effort is providing a systems evaluation of technology components and analytical techniques, which have been developed in previous years. Fabrication of an advanced technology conventional transmission and a low ratio and high ratio hybrid traction drive transmission **has** been completed. Testing of the low ratio unit is progressing. The broad specification fuels technology activity is focused on evolving and demonstrating the engine component technology required to utilize broad property fuels in current and future commercial aircraft. Preliminary evaluation of advanced combustor concepts **has** been completed and design refinements are being initiated. The advanced **low** emission combustion effort has experimentally screened the most promising combustor concepts for lean, premixed, prevaporized burning.

BASIS OF FY 1982 ESTIMATE:

The helicopter transmission systems technology efforts will be completed in FY 1982 with the conclusion of testing and evaluation of the high ratio and low ratio traction drive units and the advanced technology conventional transmission. In the broad specification fuels technology activity in FY 1982, rig testing of optimized combustor components will be completed and design and fabrication of hardware for engine verification will be initiated. The advanced low emission combustion program, which concludes in FY 1982, will focus on extensive experimental evaluation of the most promising concepts with emphasis on fuel flexibility, durability, and emission characteristics.

	1980	1981		1982
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of Dollars)		
Avionics and flight controls systems technology.. .. .	2,206	1,550	1,200	1,300

OBJECTIVES AND STATUS:

The objective of the avionics and flight controls systems technology program is to apply the fundamental knowledge gained in the research and technology base demonstrating technology readiness and promoting the transfer of advanced systems techniques to the aircraft industry through experimental testing and verification in a realistic environment.

In recent years, a significant increase in the implementation of digital systems has been made by the aircraft design community to take advantage of benefits in size, weight, power consumption and the ability to perform more sophisticated functional operations. This trend is expected to accelerate and has necessitated an improvement in the understanding of software system verification/validation technology to facilitate the checkout and certification process. Based on past experience with digital systems and simulation technology, a joint program with **FAA** is underway. Reliability and failure effects surveys, workshops conducted to apprise **FAA** personnel of current technology, and the development of a validation system based on laboratory simulation techniques have been completed.

In the controls area, flight evaluations will be completed on a technique in which backup software is embedded in the primary software structure to protect redundant flight control systems against generic software failures.

CHANGES FROM FY 1981 BUDGET ESTIMATES:

The decrease of \$350,000 reflects the Ames Research Center accounting procedure change which, beginning in **FY** 1981, budgets for the costs associated with low speed aircraft operations, supporting systems research, and simulation activities in the **low** speed systems technology program. This change will improve management visibility.

BASIS OF FY 1982 ESTIMATE:

The principle emphasis in the joint NASA/FAA activity will be the continuation of tests to develop techniques for improving the systems verification/validation process as applied to transport aircraft. The overall program is expected to provide optimum configurations to reduce flight test requirements and costs associated with the certification process.

In concert with research and technology base activities, laboratory and flight evaluations will be conducted on selected subsystem elements of an innovative flight control system architecture to provide technical data prior to the initiation of preliminary design.

	1980	1981		1982
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of Dollars)		
Aeronautical systems studies	4,134	3,600	3,200	3,800

OBJECTIVES AND STATUS:

Aeronautical system studies are conducted as a means of identifying the need for, and assessing the impact of, technology advances. The objectives of aeronautics system studies are to determine the feasibility, technology requirements, costs, benefits and impacts of advanced civil and military aeronautical systems through mission, system and conceptual design studies. The studies integrate the mutual effects of technology and a wide range of related factors.

Significant recent results include identification of technology requirements and evaluation of technology benefits for small commuter transports, multirole large transports for civil cargo and military airlift applications, and several new rotorcraft applications. Feasibility studies have also been conducted on high altitude, long-endurance sensor or data relay airborne platforms, and on potential aircraft applications of electromechanical technology advances.

CHANGES FROM FY 1981 BUDGET ESTIMATES:

The decrease of \$400,000 reflects the transfer of funding for the post-baccalaureate program to the multidisciplinary research line item in the research and technology base program element.

BASIS FOR FY 1982 ESTIMATE:

Rotorcraft studies will assess rotorcraft designs that have fully integrated the use of currently available technology compared to more advanced technologies and concepts expected to mature in a few years. Studies will be conducted of advanced Vertical/Short Take-Off and landing (V/STOL) concepts.

Long-haul transport studies will continue to focus on fuel conservation concepts and operational procedures, applications of advanced materials and subsystems, and assessments of future vehicle and transportable system concepts.

High speed system studies will continue to emphasize the potential application of supersonic cruise research technology progress to high performance combat aircraft in various mission situations. The high speed system studies will be directed at the identification of further technology needs, refinements and validation to achieve the confidence required for future military system applications.

Advanced propulsion systems studies will address potential turboprop applications for future **small**, as well as large aircraft, and will define desirable options for experimental verifications of advanced propulsion systems, such as variable cycle engines and turboprop systems.

General aviation studies will explore the feasibility of advanced vehicle and avionics concepts and evaluate the benefits of potential propulsion system and propeller advances.

	1980 <u>Actual</u>	1981		1982
		<u>Budget</u> <u>Estimte</u> (Thousands of Dollars)	<u>Current</u> <u>Estimate</u> (Thousands of Dollars)	<u>Budget</u> <u>Estimate</u>
General aviation systems technology.....	712	100	1,050	---

OBJECTIVES AND STATUS:

The purpose of the general aviation systems technology program **is** to demonstrate and verify the feasibility and availability of new technology for general aviation, thereby promoting the earliest possible transfer and utilization of new technology by industry. The program element objectives include improvements in safety, energy, efficiency and utility.

The program emphasis in FY 1981 continues to be concentrated on avionics and human factors in the general aviation Demonstration Advanced Avionics System (DAAS). The objective is to provide the critical information required by industry to proceed with the design of a reliable, **low** cost, advanced avionics system which can enhance the safety and utility of a majority of future general aviation aircraft, particularly for single pilot operation. Flight demonstration hardware has been fabricated and checked out and individual software packages (electronic horizontal situation indicator, integrated data control center, bus controller, autopilot) have been developed. Integration of the complete DAAS is proceeding with system checkout and flight tests to be conducted during FY 1981.

CHANGES FROM FY 1981 BUDGET ESTIMATES:

This increase primarily reflects the additional funding provided by Congress for general aviation/commuter aircraft propulsion research.

BASIS OF FY 1982 ESTIMATE:

No funds are requested in FY 1982. However, operational flight tests of the demonstration advanced avionics system and evaluations by NASA, industry, and selected guest pilots will be completed during FY 1982.

	<u>1980 Actual</u>	<u>1981</u> <u>Budget</u> <u>Estimate</u> (Thousands of Dollars)	<u>Current</u> <u>Estimate</u>	<u>1982</u> <u>Budget</u> <u>Estimate</u>
Low speed aircraft systems technology.. .. .	23,175	23,450	24,300	38,500

OBJECTIVES AND STATUS:

The objective of the low speed aircraft systems technology program is to provide ground-based and flight research on integrated total systems which hold promise for future civil and military applications, and on focused engineering and operational design criteria for low speed aircraft concepts and operations. Low speed aircraft include the categories of rotorcraft, Short Take-Off and Landing (STOL) and Vertical/Short Take-Off and Landing (V/STOL). The program covers the broad technology areas of configuration aerodynamics; propulsion; integrated flight systems including controls, guidance and navigation; and structural systems including advanced materials applications, aeroelasticity, vibration and acoustics. The experimental ground-based and flight testing is closely coupled with analytical and design methodology studies.

The Rotor Systems Research Aircraft (RSRA) in the helicopter configuration has begun the first flight research program on vertical drag in hover and will remain in a flight research status with the delivered rotor system through FY 1981. The RSRA vehicle in the compound configuration with a fixed wing and auxiliary propulsion has been extensively calibrated and is continuing baseline flight tests. The second XV-15 tilt rotor research aircraft has completed its contractor (Bell Helicopter Textron) development flight tests and has been accepted by the government. These aircraft are in an active flight research status at the Dryden Flight Research and Ames Research Centers. The Quiet Short-haul Research Aircraft (QSRA) was successfully utilized in a joint NASA/Navy program to evaluate the application of STOL propulsive lift technology in the aircraft carrier environment. The aircraft was then utilized in a cooperative program

in which Air Force, Navy, FAA, airframe industry, and airline pilots participated in STOL evaluations. These evaluations provided the user community with knowledge of QRA technology capabilities and NASA with guidance on additional propulsive lift research needs from the perspective of potential users. A coordinated series of small-scale, high speed tunnel model, full-scale, low speed tunnel model, and simulator tests were successfully conducted to provide a data base on a promising tilt nacelle subsonic V/STOL concept. In addition, a number of low and high speed wind tunnel investigations were conducted on several supersonic V/STOL fighter type concepts and V/STOL propulsion systems.

ANGES FY 1 BUDGET ESTIMATES:

The increase of \$850,000 reflects the Ames Research Center accounting procedure change which, beginning in FY 1981, budgets the costs associated with low speed aircraft operations, supporting system technology and simulation activities in the low speed systems technology program for improved management visibility.

BASIS OF FY 1982 ESTIMATE:

Flight research will continue in FY 1982 using the two RSRA vehicles to investigate and document basic flight characteristics with the delivered five-blade rotors. Acquisition will continue of a modern four-blade rotor system for investigation on RSRA. Also, preliminary design studies will be accomplished in a cooperative effort with the Army to define an advanced technology flight research rotor for possible use on RSRA that could enable systematic evaluation of variations in blade aerodynamic, structural, acoustic and dynamic characteristics.

The initial phases of XV-15 tilt rotor research aircraft flight research program that are aimed primarily at documenting the aircraft flight characteristics and at evaluating the capability of the aircraft in performing a number of potential civil and military missions will be completed. New composite rotor blades will be developed to provide improved aircraft performance, and adequate spare blades will be acquired for a continuing flight experiments program utilizing the aircraft.

The rotorcraft operating systems advanced technology programs will continue to utilize both ground-based simulation and flight research techniques. Research on all-weather rotorcraft capability will emphasize remote site onboard systems, evaluation of advanced navigation and guidance concepts, and operations into high density terminal areas utilizing airborne radar, NAVSTAR global positioning, and microwave landing systems. Emphasis will be on the exploration and development of advanced technology concepts that will allow rotorcraft to operate under instrument flight conditions with the same utility and flexibility as they currently have under visual flight conditions.

Advanced rotorcraft technology programs will continue to grow, focusing on coupled analytical prediction methodology and experimental verification through systematic ground-based and flight testing of a number of key rotorcraft vehicle and operating system problems. Particular emphasis will be placed on systems and problems associated with improved high

speed flight capability, on propulsion, and on large scale technology demonstration. In addition to the advanced research rotor systems associated with RSRA and the **XV-15**, a second generation advanced aerodynamic research rotor will be acquired to focus 40 x 80 foot wind tunnel investigations on the problems of conventional type helicopter rotors in operation at high forward speeds.

A modified bearingless main rotor will be tested in the wind tunnel to broaden the data base and verify design methodology for that class of advanced concept rotor. Detailed flow and pressure measurements will be made on a highly instrumented two-bladed rotor to investigate high lift, stall boundary conditions as a precursor for flight tests on an upgraded and instrumented AH-1G helicopter. Systematic full-scale rotor model research will begin on higher harmonic controls to reduce vibration. Increased emphasis will be placed on acoustic research in all rotorcraft investigations in modified 40 x 80 and new 80 x 120 foot wind tunnels. In the area of propulsion, increased emphasis will be placed on design methodology and experimental research on selected turboshaft propulsion subsystems in the helicopter size category, on power transfer and transmission technology, and on large-scale investigation of propulsion systems for high speed rotorcraft concepts which require a variable conversion from shaft horsepower to direct thrust together with high engine air bleed capability. In the area of structural systems, a special investigation will be completed to assess current unified airframe vibration prediction methods and specific needs for further research. Research will continue on active and passive techniques to reduce structural vibration and on internal noise reduction. Research on advanced composite material applications will emphasize monitoring composite airframe components in helicopter operational use and study of advanced composite structural concepts for rotorcraft airframes.

In the **V/STOL** area, both the low speed performance and control, and the high speed cruise/maneuver characteristics of several promising supersonic **V/STOL** fighter type aircraft configuration concepts will be investigated in wind tunnel tests of powered **small-** and full-scale models. The full-scale models to be tested, or in fabrication for future tests, include wing-root augmentor, rotating nozzle, and remote (forward fuselage) augmented-lift propulsion system concepts to provide vectorable thrust of the nature and magnitude required to lift and control **V/STOL** aircraft in hover and low speed flight. **V/STOL** propulsion control mathematical models will be merged with airframe control models for sophisticated ground-based simulation to define general design criteria for integrated airframe/propulsion controls. Additional simulator investigations will be undertaken to evaluate the flight characteristics of a few promising **V/STOL** concept designs. Some simulation efforts will be directed toward defining specific flight and control system characteristics which should be incorporated in corollary in-flight simulation investigations.

The **QSRA** will continue to be used for the development and verification of criteria for high propulsive-lift (**STOL**) performance levels and for associated flight control concepts and pilot displays. Means of improving the cruise efficiency (through high-speed drag reduction) without a major compromise in the low speed performance of such propulsive lift configurations will be examined using analytical and wind tunnel experimental studies.

	1980	1981		1982
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of Dollars)		
High speed aircraft systems technology	14,695	16,800	16,700	19,400

OBJECTIVES AND STATUS:

The objective of the high speed aircraft systems technology program is to generate engineering and design data applicable to the development of advanced high performance, high speed aircraft for military and civil applications. The program objective is accomplished by detailed and extensive studies and analyses, ground-based simulations and wind tunnel experimental research and flight tests.

The supersonic cruise research activity has continued to address high potential technologies in the critical disciplines of aerodynamics, high temperature materials, lightweight long-life structures, and engine/airframe integration. During the past year, significant advancements were made in structures with a single step process fabrication of large complex grid titanium panels by the superplastic forming and diffusion bonding technique. Supersonic wind tunnel tests of a variable area axisymmetric inlet were successfully accomplished demonstrating stable operations Over a range of speeds and angles of attack and yaw.

During the past year, the flight experiments effort included the successful validation of a NASA-conceived aileron-to-rudder interconnect control system on an F-14 aircraft as part of a joint NASA/Navy program to improve high angle-of-attack flight characteristics. Major progress was made on two elements of the joint NASA/Air Force advanced fighter technology integration project involving integrated fire/flight controls in an F-16 aircraft and a mission adaptive wing on a F-111 aircraft. The Highly Maneuverable Aircraft Technology (HiMAT) effort successfully flight demonstrated the primary maneuverability design point and continued to expand the flight envelope of the remotely-piloted research vehicles involved in this activity.

CHANGES FROM FY 1981 BUDGET ESTIMATES:

The decrease of \$100,000 reflects the net result of the change in accounting procedures at Ames Research Center which now captures wind tunnel operational costs under the high speed and low speed systems technology programs, and the rebalancing of program support costs.

BASIS FOR THE FY 1982 ESTIMATE:

In FY 1982, the supersonic cruise research efforts will continue in all the critical discipline technologies. Aerodynamics will use wind tunnel testing of high speed models to validate high lift-to-drag ratio estimates and determine stability characteristics. More fuel efficient unconventional configurations such as multilobe over and under or side-by-side fuselage designs will be included. Materials and structures activities will emphasize high temperature composites and advanced metallics, including related fabrication techniques, aimed at lower weight and reduced manufacturing costs. In FY 1982, airframe/propulsion integration will receive additional emphasis for inlets and nozzles. The variable area axisymmetric inlet will be tested for its low speed performance and acoustic characteristics, and the acoustic heat shield concept will be investigated to establish its capabilities for significant nozzle noise suppression.

The flight experiments activities in FY 1982 will involve tests using a variety of high performance aircraft to investigate critical and new concepts. As part of the continuing joint NASA/Navy project, the F-14 aircraft will be flown at angles-of-attack for inlet distortion measurements. Initial flights of the variable camber mission adaptive wing on the Advanced Fighter Technology Integration (AFTI) F-111 aircraft will be made in N 1982. Extensive testing for the advanced digital flight control system in the AFTI/F-16 aircraft will occur prior to its integration with the fire control system. Both AFTI flight test activities will be performed by the joint NASA/Air Force test team.

In FY 1982, the Highly Maneuverable Aircraft Technology (HiMAT) vehicles will be flown to achieve valid flight environment experimental data on the aeroelastically tailored graphite composite wing/canard structure at critical flight conditions. Both RPRV aircraft will be used to complete the flight assessment of the aerodynamics, both performance and stability and control, of the closely coupled wing/canard design incorporated in the HiMAT vehicles. Tests will include maneuvering at different speeds and altitudes with reduced and negative aerodynamic stability, and the utility of the remotely-piloted research vehicle approach for high risk technology testing will be determined.

	1980	1981		1982
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of Dollars)		
Transport aircraft systems technology.. .. .	57,891	33,500	33,100	31,400

OBJECTIVES AND STATUS:

The objective of the transport aircraft systems technology program is to develop and demonstrate advanced technology for enhancing aircraft energy efficiency and providing operational compatibility with the future National Aerospace System.

Laminar flow control is a technology with great potential for drag reduction and, hence, fuel savings. The unsolved problems lie in the difficulty of producing wings of sufficient smoothness and uniform suction and in maintaining the quality of the wing surface in normal operations when clouds, ice particles, insects, and dust are encountered. Major development contracts have been awarded which will lead to providing operational experience with wing leading edge systems, continued development of promising wing surface systems, and providing verification of the suitability of advanced airfoils for laminar flow control.

The energy efficient transport activity will develop and evaluate advanced aerodynamics, propulsion/airframe integration, and active controls technology for both near-term and long-range application to transport aircraft. In FY 1981, in-house activity is focused on active control system definition and component development. Fabrication and assembly of the advanced research wing (ARW-2) will continue through FY 1981 in preparation for flight tests in FY 1982. Three major contract activities with Boeing, Douglas, and Lockheed continued with the development of selected near-term concepts for increasing fuel efficiency. In FY 1981, Boeing will continue the integrated application of active controls to the design of an energy efficient transport. Douglas will concentrate on the hardware fabrication and preparation for flight tests of winglets on the DC-10. Lockheed will initiate first flight tests of an interim control system for reduced static stability.

The objective of the composite primary aircraft structures efforts is to accelerate the introduction of weight and cost saving composite secondary and medium primary structures in future derivative and new commercial transport aircraft. This is being accomplished through design, fabrication and certification of six representative composite components. During N 1981 three secondary components were completed and in flight service. Fabrication and component ground-testing is underway on the three medium-sized primary components. The first flight of a primary composite structure on a commercial aircraft was achieved at the beginning of FY 1981 with the flight of the composite stabilizer on a Boeing 737. Fabrication and ground testing of the vertical fins for the Lockheed L-1011 and the Douglas DC-10 will

continue, as will the accelerated life test program. In support of larger primary structures, **small** subcomponents will be designed and fabricated for investigations of fuel containment, crashworthiness and durability, and techniques for designing critical joints and connectors for composite structures.

The objective of the terminal configured vehicle program is to develop airborne systems technology and flight procedures which will lead to safer and more productive terminal area operations. Major attention is being focused on the avionics, displays, airborne systems, and interfaces between the pilot and the air traffic control system which will help reduce approach and landing accidents, passenger delays, fuel consumption, and the noise levels in the vicinity of major airports. Present activities include experiments which further characterize efficient descent and approach paths and use of the microwave landing system, area navigation, precision path control, and onboard displays to improve airspace, runway, and crew utilization.

CHANGES FROM FY 1981 BUDGET ESTIMATE:

The decrease of \$400,000 reflects the Ames Research Center accounting procedure change which, beginning in FY 1981, budgets for the costs associated with low speed aircraft operations, supporting systems technology and simulation activities in the low speed systems technology program for improved management visibility.

BASIS OF FY 1982 ESTIMATE:

In laminar flow control, the areas of emphasis in FY 1982 will include evaluation of cost-effective manufacturability of the slotted, perforated, and porous wing surface structure concepts and their ability to withstand flight loads in ground tests. Evaluation of wing leading-edge contamination will be made, where surface roughness, particularly due to insect residue, is a potentially serious problem. High speed wind tunnel tests of an advanced airfoil incorporating laminar flow control features will be conducted.

In the energy efficient transport program, in-house activities will be focused on the final evaluation of the fault tolerant computer systems and the flight test of the advanced research wing. All three contract activities will be in the flight test phase of the concepts fabricated in FY 1981.

In the composite primary aircraft structures program the remaining two medium-sized primary components, the vertical fins for the L-1011 and DC-10, will enter flight testing. The accelerated fatigue and environmental effects life testing will continue. Under the key technologies for the large structures effort, experimental testing of a series of subcomponents will be completed.

During FY 1982, studies will be directed toward a large composite primary aircraft structures program which will provide a verified technology base for the use of graphite composite materials in the fabrication of lighter weight,

lower cost primary structures. Full application of secondary and medium primary composite components on a transport aircraft will yield a fuel saving of approximately two percent. Use of composites in primary structures provides a 10-12% improvement. A major technology development program is required to resolve critical problems in the design and fabrication of a very large, thick, highly loaded sections from graphite composite materials. As with the composite secondary and medium primary components, the large composite primary aircraft structures program activities would be carried **out** principally under contract to industry. In future years, three multiyear, cost-shared contracts would be **awarded** to Boeing, Douglas, and Lockheed to design, build, and test full-scale sections of the major load carrying structure of a representative transport wing. Out year efforts will address application of these techniques to fuselage construction as well.

In FY 1982 the terminal configured vehicle program will continue to involve industry, airline flight crews, and FAA in concept analysis, development, and validation to acquire user understanding and acceptance. Interactive simulation and flight experiments with the air traffic control system will be conducted. Advanced flight deck developments using sophisticated electronic displays, digital avionics, and the accurate management of thrust and performance will also be carried out.

	1980 <u>Actual</u>	1981		1982
		<u>Budget Estimate</u> (Thousands of Dollars)	<u>Current Estimate</u>	<u>Budget Estimate</u>
Advanced propulsion systems technology.. .. .	72,278	50,700	47,800	38,800

OBJECTIVES AND STATUS:

The objective of the advanced propulsion systems technology program is to achieve improved performance, lower fuel consumption, and reduce noise and emissions from future aircraft engines through the integration of improved propulsion components .

The component development and integration phase of the energy efficient engine program continues. Full-scale component rig testing is proceeding as planned. Tests of the front stages of the advanced 23:1 pressure ratio compressor for the General Electric engine design achieved performance goals. Sector testing of the Pratt & Whitney, two-stage combustor **has** been successfully completed. In FY 1981, tests of all major engine components will be completed. In the advanced turboprop program, progress continues in the aerodynamic, acoustic, and structural aspects of advanced turboprop propulsion systems. Emphasis in FY 1981 will be on obtaining definitive data on noise at cruise conditions, fuselage noise attenuation, efficient wing mounting, and large-scale blade design. In the variable cycle engine program, **aero/acoustic** testing of the core-driven fan system will be completed during the first half of FY

1981. This includes an assessment of the additional noise reduction capabilities of a mechanical suppressor and a treated shroud operating in conjunction with the coannular exhaust nozzle system. Effort on other advanced suppression techniques such as thin sheath thermal shielding will continue through the year. In addition, effort will be initiated in FY 1981 on critical low-spool technologies unique to this propulsion concept. This will include designs of a variable flow fan, a flight-type duct burner, and an advanced single-stage turbine. As recommended by the Congress, effort will be initiated in FY 1981 on high-spool components with emphasis on the application of advanced materials, coatings, and cooling technologies to the core turbine and primary combustor.

CHANGES FROM FY 1981 BUDGET ESTIMATES:

The decrease of \$2.9 million reflects a net combination of additional funds provided by Congress for high temperature engine core technology in support of the variable cycle engine program (\$3.5 million), and the overall Congressional reduction in appropriations requested resulting in rephased funding in the energy efficient engine program (\$6.4 million).

BASIS OF 1982 ESTIMATE:

In the energy efficient engine program, the first integrated system test of the high-spool components assembled in a gas generator core engine will be conducted in FY 1982. Fabrication, final assembly, and checkout of the integrated core and low-spool system will also be completed in preparation for tests planned for early FY 1983.

The variable cycle engine technology program will continue to focus on development and demonstration of the critical low-spool technologies unique to a variable cycle propulsion system. Fabrication and rig testing of advanced component designs of a simplified duct burner, a variable flow fan, and a single stage turbine will continue through FY 1982. Significant effort will also be directed towards advanced suppression techniques which can provide additional noise reduction benefits for future supersonic cruise aircraft with minimal operational/performance penalties. Advanced coannular/suppressor nozzle systems which incorporate mechanical suppressors, thin sheath thermal shields, and other promising concepts will be evaluated for both acoustic and aerodynamic performance. Effort will also be initiated in FY 1982 towards verification of the coannular nozzle noise reduction benefit at forward velocity. This will include model tests preparatory to a flight demonstration on the NASA JetStar aircraft and modification of the VCE test system for acoustic evaluations in the NASA Ames 40 x 80 foot wind tunnel.

The advanced turboprop program activity will emphasize large-scale propellers and the gas turbine drive system which will power ground tests. A contract will be let in late FY 1981 for the design and fabrication of propeller blades for the approximately 10-foot-diameter rotors for the ground test program. A FY 1982 contract will cover the procurement and modification of the drive system, the determination of high speed wind tunnel testing feasibility and, in later years, the conduct of the propeller ground testing. In other activities, installation aerodynamics and fuselage noise

attenuation experiments **will** be refined, leading to improved predictions of turboprop benefits and definition of test bed aircraft configurations. Efficient engine inlet designs will be derived in a complementary effort.

	1980	1981		1982
	<u>Actual</u>	Budget <u>Estimate</u>	Current <u>Estimate</u>	Budget <u>Estimate</u>
		(Thousands of Dollars)		
Numerics1 aerodynamic simulator	---	---	---	16,000

OBJECTIVES AND STATUS:

A primary objective of the Numerical Aerodynamic Simulator (NAS) project is to design and develop a unique, large-scale, high performance computational resource for solving viscous, three-dimensional fluid-flow equations specially oriented toward the solution of aerodynamic and fluid dynamic problems. A secondary objective is to generalize the computational resource for application to a broader scope of problems of interest to NASA. World leadership in aerodynamics will soon belong to the country with the greatest computational capability, and superior aerodynamics is an essential element in the design of superior aircraft. The Europeans and Japanese are making rapid progress in the area of aerodynamics. They are buying or building a computational capability at least equal to ours. Further, the Japanese are planning a computer of the NAS class. In order to maintain world preeminence in both aerodynamics and computer technology, NAS will be required.

The Numerical Aerodynamic Simulator **will** be used in all phases of aeronautical research and development, including basic research, preliminary aircraft component design, and aircraft configuration refinement and optimization. In the area of basic research, it will permit investigations, at a level of detail currently impossible, into the physics of important fluid dynamic phenomena such as boundary-layer transition, turbulence, flow separation and reattachment, and the origin of aerodynamic noise. Essentially first-principle calculations **will** provide the indepth understanding that is required in the evolution of new concepts for reducing aerodynamic drag and noise and for increasing propulsion system performance. In preliminary design, the numerical aerodynamic simulator will be used to numerically explore a very large number of aircraft components and configurations to a greater technical depth than is currently economically feasible. This **will** lead to more refined initial designs before commitment is made to begin costly and time-consuming wind tunnel tests thus increasing the productivity of the Nation's major wind tunnels. In the configuration refinement and optimization phase of development, it **will** provide the opportunity to use powerful numerical optimization methods to refine components of configurations in combination rather than separately so as to minimize undesirable interference between components ■

These applications to aircraft design problems will significantly constrain the rapidly escalating cost of development of new aircraft. Although primary use will be for aerodynamic work, some time will be available for pioneering work in other disciplines that require large scientific computers; for example, work in propulsion technology, weather and climate modeling, computational chemistry, computational astrophysics, and structural analysis will be possible. The initial emphasis is to design and construct an advanced computer with the capability to perform the wide range of needed flow simulations. The computer required will need substantially more memory and speed (memory of 240 million words and speed of 1000 million floating point operations per second) than is available or planned by the computer industry for the foreseeable future. Preliminary and feasibility studies have demonstrated that it is practical to build a computer with these characteristics using the best state-of-the-art microelectronics. The design definition (phase B) studies are underway and the request for proposals for the detailed design, construction, and integration (phase C/D) contract will be issued in early FY 1982.

BASIS OF FY 1982 ESTIMATE:

Preliminary project studies have indicated that three important functions should all be accomplished within the first eighteen months of the NAS project; detailed design of the processing system, complete computer simulation of the detailed design, and purchase of the front-end (support) computer system on which to conduct the simulation. The FY 1982 budget will permit these and other associated critical activities to be initiated and substantially advanced during FY 1982.

In the near-term, major emphasis will be on design, design validation, and engineering plans of the advanced numerical processor, the integrated supported processor, and the user interface system. These system design and engineering efforts, to be carried out by major computer manufacturers, will provide system architecture, detailed logic design and hardware specification, and critical component prototyping and simulation. In addition, these studies will provide detailed cost and schedule estimates for the final design and fabrication phase. Concurrent with the computer system studies, the architectural design of the building to house the numerical aerodynamic simulator will be carried out. Following these efforts, and subject to appropriate reviews and approvals, NASA will award contracts for the fabrication of the simulator and associated systems.

SPACE
RESEARCH AND
TECHNOLOGY

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1982 ESTIMATES

BUDGET SUMMARY

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

SPACE RESEARCH AND TECHNOLOGY PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1980 <u>Actual</u>	1981 <u>Budget Estimate</u> <u>Current Estimate</u> (Thousands of Dollars)		1982 <u>Budget Estimate</u>	Page No.
Research and technology base	99. 816	100.300	101. 100	124. 800	RD 10-3
Systems technology programs	10. 770	7. 800	7. 500	13. 200	RD 10-19
Standards and practices	<u>5. 000</u>	<u>2. 100</u>	<u>2. 100</u>	<u>3. 000</u>	RD 10-23
 Total	 <u>115. 586</u>	 <u>110. 200</u>	 <u>110. 700</u>	 <u>141. 000</u>	
 <u>Distribution of Program Amount by Installation:</u>					
Johnson Space Center	10.287	8. 000	8. 400	10. 100	
Marshall Space Flight Center	8. 920	7. 050	7. 000	11,700	
Goddard Space Flight Center	9. 436	9. 100	9. 000	12. 400	
Jet Propulsion Laboratory	23. 071	19.300	19. 700	24. 900	
Ames Research Center	8. 968	9. 500	9. 800	12. 000	
Dryden Flight Research Center	---	---	100	100	
Langley Research Center	27. 411	28. 100	28. 700	36. 200	
Lewis Research Center	22. 228	25. 200	25. 000	29. 700	
Headquarters	<u>5. 265</u>	<u>3. 950</u>	<u>3. 000</u>	<u>3. 900</u>	
 Total	 <u>115. 586</u>	 <u>110,200</u>	 <u>110,700</u>	 <u>141. 000</u>	

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1982 ESTIMATES

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

SPACE RESEARCH AND TECHNOLOGY PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objectives of the Space Research and Technology program are to provide the technology base necessary to support current and future space activities, to formulate technology options for the future, and to advance technology in order to reduce further the costs of space activities.

The FY 1982 program supports these objectives by stressing technology areas judged to be most critical by advisory groups, a special in-house assessment, and in-house users of the technology. This technology is needed to enhance planned missions and to enable accomplishment of missions which are beyond current capabilities. Emphasis **will** be directed to the identification and development of fundamental and system technologies to support the development of information systems, transportation systems, and spacecraft systems that will enable future low cost missions. When required, the program demonstrates the readiness of new technology by space or ground experiments to assure its acceptance for utilization in planned missions.

CHANGES FROM FY 1981 BUDGET ESTIMATE:

The net increase of \$500,000 reflects additional funds provided by the Congress for increased emphasis in advanced propulsion and large space structures (\$3.0 million), partially offset by the application to this program of a portion of the general Congressional reduction (\$2.5 million) in the overall appropriation requests which has been distributed across many program elements as addressed below. Additionally the funding levels of several disciplines within the research and technology base have been rebalanced to further augment the priority advanced propulsion efforts which will provide for increased future space propulsion capability for the Nation. Other minor realignments within the research and technology base disciplines reflect a revision to the ~~Ames~~ Research Center method of budgeting for their thermo-gas dynamics facilities. The operational costs were previously funded under several of the research and technology disciplines. Beginning in FY 1981, this activity will be budgeted in the aerothermodynamics research and technology discipline for increased management visibility.

BASIS OF FY 1982 ESTIMATES:

FY 1982 estimates for the research and technology base include an increase of about ten percent above the inflation adjustment over the FY 1981 level. This reflects recognition that basic research and technology must be strengthened if

we are to maintain a strong research and technology base in the disciplines of aerodynamics, chemical propulsion, materials and structures, electronics and automation, space power and electric propulsion. These efforts will continue to provide the technology base for future missions requiring information, spacecraft and transportation systems.

In FY 1982, systems studies will continue to focus the discipline and system activities in directions which will provide the maximum benefits from available resources.

BASIS OF FUNDING REQUIREMENTS:

<u>RESEARCH AND TECHNOLOGY BASE</u>					
	1980	1981		1982	Page
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>	<u>No.</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>	
		(Thousands of Dollars)			
Aerothermodynamics research and technology.....	5,400	5,900	7,800	8,700	RD 10-4
Chemical propulsion research and technology..	8,900	9,000	12,400	16,600	RD 10-5
Materials and structures research and technology..	15,376	16,000	14,000	17,500	RD 10-7
Electronics and automation research and technology..	8,123	8,500	7,900	11,000	RD 10-9
Space power and electric propulsion research and technology.....	19,364	19,700	19,200	21,800	RD 10-11
Multidisciplinary research and technology.....	2,644	2,800	2,700	5,200	RD 10-12
Information systems research and technology..	21,847	21,900	21,300	25,000	RD 10-13
Spacecraft systems research and technology.....	7,437	8,500	9,000	10,300	RD 10-15
Transportation systems research and technology..	10,725	8,000	6,800	8,700	RD 10-17
Total.....	<u>99,816</u>	<u>100,300</u>	<u>101,100</u>	<u>124,800</u>	

	1980	1981		1981
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of Dollars)		
Aerothermodynamics research and technology.. .. .	5,400	5,900	7,800	8,700

OBJECTIVES AND STATUS:

The objective of this effort is to expand the understanding of the aerothermodynamic, gas dynamic, and flight mechanics problems associated with atmospheric entry and/or upper atmosphere maneuvers of spacecraft designed for Earth orbital missions and planetary exploration. This knowledge will be applied to the improvement of the safety, reliability, and efficiency of such spacecraft.

In the area of space vehicle configuration and aerothermodynamics, technology assessment studies have indicated that for advanced, heavy lift, single-stage-to-orbit vehicles, the far-aft-center of gravity location (greater than 75 percent of length) is a major design issue. This issue must be addressed and solved before advantages associated with advanced technology can be realized. In the area of planetary entry probes, the capability has been developed to calculate the turbulent flow field about a massively ablating sphere/cone entry body during descent through the atmosphere of Jupiter. In the flight data analysis effort, several experiments to be conducted on the Shuttle orbiter are under construction. These experiments will provide research quality data for use in evaluating theoretical and ground-based experimental methods, as well as provide for an increased data base for future design problems.

CHANGES FROM FY 1981 BUDGET ESTIMATES:

The increase of \$1.9 million primarily reflects the change in the method the Ames Research Center (ARC) uses to account for in-house operations costs. This increase reflects that the aerothermodynamics research and technology base element will fund the full costs of the thermo-gasdynamic facilities at ARC.

BASIS OF FY 1982 ESTIMATE:

In the area of space vehicle configuration and aerothermodynamics, efforts are aimed at improving vehicle performance and reliability and reducing costs for a variety of potential space missions. In FY 1982, continued emphasis will be placed on development of theory, advanced computational methods, and computer codes for predicting vehicle flow fields and performance; development of improved ground-based experimental techniques, instrumentation and simulation capability; provision of advanced vehicle design integration capability; and development of a data base from ground facility and flight investigations for support of future vehicle design.

The planetary probe technology effort provides the aerothermodynamic base which supports current and future scientific missions to study the atmospheres of Venus, Mars, the outer planets, and certain of their satellites. This technology base is used in the design, development, and verification of planetary probe configurations, and provides the flight mechanics data in support of atmospheric reconstruction experiments. In FY 1982, theoretical and experimental efforts will be pursued to develop a data base to be used to minimize planetary mission costs, to maximize the scientific returns, and to insure a high probability of mission success.

The flight data analysis effort will use the orbiter experiment flight data to study phenomena which cannot be simulated in ground facilities, to develop techniques for extrapolating ground facility results to flight conditions, and to verify analytical and computational prediction techniques. In FY 1982, analysis techniques and associated software will be developed in preparation for analysis of flight data.

The payload capability of reusable transfer vehicles to geosynchronous orbit can be enhanced by approximately a factor of two by employing an aero— ssisted maneuver upon return to low Earth orbit. The planetary probe investigation of rarefied gas flows will be expanded to characterize flow—field effects for aero— assisted orbital transfer vehicle concepts.

	1980	1981		1982
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of Dollars)		
Chemical propulsion research and technology.. .. .	8,900	9,000	12,400	16,600

OBJECTIVES AND STATUS:

The objective of the chemical propulsion research and technology program is to develop technology to improve the performance, flexibility, life, and reusability of liquid rocket propulsion systems for future space transportation vehicles and planetary spacecraft. The program involves technology for advanced Earth—to— orbit propulsion, orbital transfer propulsion, low thrust spacecraft propulsion, in—space cryogenic fluid management, and advanced high pressure, oxygen—hydrogen engines. Advanced concepts that give promise of greatly exceeding the performance capability of standard chemical propulsion systems are also evaluated.

In FY 1981, a major redirection of the program was instituted that places increased emphasis on the development of a technology base for advanced high pressure, oxygen—hydrogen engines. This will provide technologies primarily for advanced future engines but may also prove useful in any possible future upgrading of the Space Shuttle main engine beyond its original design capabilities. Technical accomplishments in FY 1981 include the successful demonstration of

hybrid bearings for **small**, high pressure, liquid hydrogen pumps and a combustor ceramic coating that increased combustor low-cycle thermal fatigue life by a factor of ten. In addition, a small charge of heat-sterilized solid propellant **was** fired in a test motor for the first time and an electrolysis cell for decomposing carbon dioxide in order to produce oxygen from the Martian atmosphere for propellant to return to Earth **was** successfully demonstrated.

CHANGES FROM FY 1981 BUDGET ESTIMATES:

The increase of \$3.4 million reflects additional funding for advanced propulsion research and technology provided through the rebalancing of other space research and technology base discipline funding to support this high priority advanced propulsion activity.

BASIS OF FY 1982 ESTIMATE:

Research and technology for Earth-to-orbit propulsion will continue to focus on fundamental work in the areas of combustion, stability, heat transfer and cooling for both primary and auxiliary propulsion systems. Primary emphasis in FY 1982 will continue to be on oxygen-hydrocarbon propellants. This technology will provide the basis for optimizing performance, life, reliability, and maintainability of this class of propulsion system.

The expanded effort in high pressure, oxygen-hydrogen engines that **was** initiated in FY 1981 by adjusting funds within the ongoing program will continue in FY 1982. The work involves extending turbomachinery life and performance through improved bearings, seals, and turbine blade designs, and through a better understanding of the dynamic behavior of rotating shafts and pump hydrodynamics. Combustion, heat transfer, and advanced nozzle technology efforts will be directed towards increasing combustor life and performance. Advanced sensor concepts will be explored that could provide an in-place engine monitoring and inspection capability for rapidly determining flight readiness in order to greatly reduce turnaround times between flights. These technologies will be supported by a strong effort in advanced materials evaluation and development, including fracture and fatigue life characteristics.

The orbital transfer propulsion effort will encompass critical component technology for advanced expander cycle engines. The emphasis will be on high heat transfer combustors and advanced high expansion ratio nozzles for more efficient operation of both high and **low** thrust levels. Effort will also continue towards characterizing dedicated low thrust propulsion systems in terms of propellant choice, thrust level, combustion pressure, cooling losses, and expansion ratios, for maximum performance and life. This technology will provide the basis for propulsion system selections for both high and low thrust orbital transfer missions.

Low thrust spacecraft propulsion research and technology will continue to focus on advanced planetary retropropulsion systems. Future missions will require increased capability for retro- and in-orbit maneuvers and high reliability to insure a ten-year operational life. In FY 1982, **small** pump and pump drive concepts will be evaluated and selected and thruster operating limits will be defined as a function of thrust level, operating pressures, and expansion ratios.

Research in the area of in-space cryogenic fluid management includes conceptual design and analysis studies of proposed flight systems supported by ground-based testing in vacuum chambers and drop tower facilities. In FY 1982, work will continue towards completing the design of an in-space cryogenic fluid management facility that will be used to study the storage, positioning, expulsion and transfer of liquid hydrogen for application to future orbital transfer vehicles and in-orbit refueling stations.

		1981		1982
	1980	Budget	Current	Budget
	<u>Actual</u>	<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of Dollars)		
Materials and structures research and technology.. .. .	15,376	16,000	14,000	17,500

OBJECTIVES AND STA

The objective of this activity is to develop the technology in advanced materials and structures for improving the performance, efficiency, durability and economy required for large area space structures for antennas and platforms, advanced space power generation, advanced space transportation systems, orbiting spacecraft and planetary probes, and payloads. Areas of emphasis include: (1) basic understanding of material science, including advanced metallics and intermetallics, long duration environmental effects of space, tribology, computational chemistry and surface physics, and bearings, lubricants and seals technology; (2) development of composites, including both polymeric and metal matrices and the identification of environmental effects and damage mechanisms; (3) development of metallic and non-metallic thermal protection systems; (4) definition of loads, dynamics and aeroelasticity of aerospace vehicles, payloads and spacecraft systems; and (5) development of advanced structural concepts, integrated analysis, and synthesis techniques for design and qualification procedures involved in new systems with operational requirements well beyond the current state of technology.

A major research effort is being directed at determining the durability of metallic and nonmetallic structural composite materials and identifying the significant damage mechanisms so that synthesis of resistant materials can be achieved. Work is continuing on high temperature resin matrix composites and new fibers for metal matrix composites to achieve higher performance levels in space structures. Fundamental work on friction and wear, directed at higher temperature, longer life bearings and seals, continues to demonstrate that improvements are possible. Several products previously developed are now being used in critical areas of the Shuttle orbiter. Advanced thermal protection systems for both space transportation systems and planetary probes are under evaluation. Several advanced insulation systems have progressed to the point that the technology can be incorporated into the Shuttle. In FY 1981, the definition phase

for the metallic thermal protection system experiment, including orbiter compatibility, has been completed. Design and procurement of the developmental thermal protection system panels is underway. The experiment will be flown in FY 1984 to demonstrate possible advantages of a metallic system over existing ceramic tiles. Definition of the structural temperature experiment was completed. This experiment will provide verification of thermal load design criteria by measurement of actual thermal gradients on the orbiter. In FY 1981, the definition phase of a potential Shuttle flight experiment to measure orbiter internal structural temperature distributions was initiated. The measured data will be used to validate thermostructural analysis methods under development. Nonlinear analysis and synthesis techniques for dynamic and thermal response, stability and control, and structural design, including optimization, are being developed for advanced space transportation systems, payloads, large space structures, and spacecraft. Erectable and deployable platform configuration concepts have been developed, and a ground test program to verify deployment dynamics and assembly techniques is in progress.

CHANGES FROM FY 1981 BUDGET ESTIMATES:

The decrease of \$2.0 million primarily reflects the Ames Research Center accounting procedure change, further reductions to provide funds to support increased advanced propulsion efforts, and further decreases in response to the Congressional reduction to the overall appropriation requests.

BASIS OF FY 1982 ESTIMATE:

Basic research activities in FY 1982 will cover corrosion, chemisorption, catalysis, hydrogen embrittlement, fiber-matrix interface properties, and lifetime prediction in elastomeric systems. An improved understanding of these phenomena and processes will provide the foundation for improving performance of space materials. In FY 1982, increased attention will be given to the effect of the space environment on the properties of composite materials. Materials which have good long-term resistance to space radiation will be identified. Aluminum matrix composites will be evaluated for the feasibility of low cost forming and enhancements possible with new fibers such as aluminum, silicon carbide and specially-coated boron. Liquid and solid lubricants will be studied for their stability at high temperatures and in vacuum. High pressure seal concepts will be evaluated in a simulated turbopump. Studies will be initiated to examine the characteristics of intermetallic aluminides for high strength to density applications.

Thermal protection concepts and materials (both metallic and nonmetallic) will continue to be evaluated for the protection of re-entry vehicles and planetary probes. In FY 1982, emphasis will be on obtaining better understanding of fundamental material surface behavior through the application of computational chemistry. For insulating heat shields, the emphasis will be on evaluating refractory fibers capable of withstanding temperatures as high as 3500°F. Candidate heat shield materials for planetary and solar probes will also be developed and tested to evaluate their performance.

In FY 1982, research and technology efforts will continue the evaluation of selected structural concepts for deployable and erectable space systems and the identification of design and qualification procedures required to meet possible future mission requirements.

In the area of integrated analysis and synthesis methods, emphasis will be on improved computational efficiency and continued development of structural modeling and analysis methods to meet the design needs of future space systems. This activity will include nonlinear behavior due to large deformations and nonisotropic composite material application, fatigue life of advanced metallic and composite materials, and structural/controls dynamic interactions.

In loads, dynamics, and aeroelasticity, the focus will include the payload ~~mass~~ and stresses and vibroacoustic design methods for adaptation to Shuttle-type vehicles, the development of concepts for control of structural dynamic modes of space systems, and improved methods of dynamic model testing.

The high temperature structures effort will continue development of metallic structures for Earth entry vehicles capable of withstanding temperatures of 1500°F or more, metallic multiwall thermal protection systems, and validated thermal stress prediction methods.

	1980	1981		1982
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of Dollars)		
Electronics and automation research and technology... ..	8,123	a, 500	7,900	11,000

OBJECTIVES AND STATUS:

The objective of the electronics effort is to provide advanced electromagnetic concepts, technology and devices needed to improve the electronics, sensing and detecting capabilities required for future terrestrial, planetary, galactic, and extragalactic missions. Laser research activities have recently provided a technique for measuring atmospheric species and winds, as successfully demonstrated by the measurment of ozone in the Pasadena, California area. A new copper halide laser ~~was~~ developed and selected for meteorology studies by the Office of Space and Terrestrial Applications. It has ideal characteristics for obtaining vertical atmospheric profiles important to the Earth's radiation budget and optical visibility due to pollution. The program emphasis is shifting from completion of the development of existing concepts to exploration of new concepts.

The autormtion activity provides the theoretical and technology base needed to expand the application of automation to greatly increase the productivity and effectiveness of humans, spacecraft , space operations and facilities. This is accomplished through basic research and synthesis and adaption of nonaerospace automation technology to space oriented problems. Basic theories of autormted general problem solving are being developed to the stage that they can treat realistic space automation-type situations, such as automatic experiment sequence generation for use in planetary probe missions. Portions of an automatic general problem solving system have been implemented in the laboratory. For example, an automatic command sequence generator ~~was~~ recently demonstrated which could have commanded Voyager to take images of the Jwian Red Spot in place of the manual logic that ~~was~~ utilized. In robotics research, hand-eye coordination ~~has~~ been demonstrated for simple assembly tasks.

CHANGES FROM FY 1981 BUDGET ESTIMATES:

The decrease of \$600,000 primarily reflects the ~~Ames~~ Research Center accounting procedure change, rebalancing of the space research and technology base disciplines to provide additional funding for advanced propulsion efforts, and the Congressional reduction to the NASA appropriation request.

BASIS OF FY 1982 ESTIMATE:

The electronics program will continue to investigate the physical phenomena associated with advanced detectors. New laser technology concepts, models and components will be developed to prvide significant advances in laser technology. Emphasis will be on new solid state imaging techniques, high density and high reliability integrated circuits, and mission cost-effectiveness by optimizing component functions. This and related technologies in sensing and detection will considerably increase system sensitivity, extend observable wavelength capabilities into the far infrared regime and increase data recording capacity and real-time processing capability. During FY 1982, the automa~~tion~~ effort will be expanded to include those aspects of machine intelligence and robotics needed to increase autonomy of space systems as a step toward ~~making~~ space missions more affordable. In particular, automatic sequence generation for orbital missions will be expanded and systems architecture formulated for autonomous spacecraft and telerobots.

	1980	1981		1982
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of Dollars)		
Space power and electric propulsion research and technology.. .. .	19,364	19,700	19,200	21,800

OBJECTIVES AND STATUS:

The objective of this activity is to provide the research and technology for major advances in the generation, conversion and transmission of energy and high specific impulse electric propulsion systems. Advances in all of these areas are needed to extend our capabilities in near-Earth space and in the exploration of the solar system.

The development of an alkaline battery failure model has resulted in an improved prediction capability for battery cycle life. In the photovoltaic area, significant progress in the understanding of radiation damage and thermal annealing properties of silicon and gallium arsenide solar cells has been achieved. During last year a laser solar pumping apparatus was assembled. A program to synthesize and characterize new, high efficiency, thermoelectric materials has identified rare Earth sulfides as a class of materials to be developed. These materials are candidate converters for use with nuclear reactors. The ion thruster technology readiness program for interplanetary missions has been completed and the technology has been transferred to both the NASA and industrial stage developers. A cooperative effort with the Air Force on high voltage plasma interactions has been initiated. An effort to identify advanced space propulsion concepts has also been started.

CEANGES FROM FY 1981 BUDGET ESTIMATES:

The decrease of \$500,000 is part of the Congressional reduction to the FY 1981 NASA appropriation request.

BASIS OF FY 1982 ESTIMATES:

Photovoltaic research and technology will continue efforts which improve conversion efficiency, reduce mass, reduce cost and increase operating life of photovoltaic converters and arrays. In the area of cells, attention will be focused on demonstrating the feasibility of an eighteen percent efficient silicon cell and evaluating thin cell approaches for gallium arsenide. The understanding of radiation damage and thermal annealing in order to increase operating life will be pursued. The solar array technology emphasis will be on low concentration ratio arrays for high power-to-weight ratio and low cost. In advanced energetics, assessments of advanced concepts for space energy generation, conversion,

storage and distribution will be performed. Critical experiments required to determine feasibility of these concepts will be initiated. Work will continue on investigations of direct conversion of solar energy into laser radiation, on novel means to convert solar and laser radiation efficiently to electricity, and on photochemical cell technology, liquid drop radiators and inertial energy storage.

In electric propulsion, the performance of mercury ion thrusters will be extended to higher power and thrust density, and the range of useful specific impulse will be broadened. An evaluation of magnetoplasmadynamic thruster performance and internal erosion characteristics will be completed. The feasibility of inert gas (argon and xenon) thrusters will emphasize increased efficiency and broadening of the operating regime.

In power management, work will be directed toward advanced components such as transistors, inductors and power transfer devices. The development of a solar thermoelectric generator will be completed. A cooperative effort with the Air Force on high voltage space plasma interactions will focus on analytical modeling. A program in technologies related to thermal management of future high power systems will be augmented.

In thermal-to-electric energy conversion, the demonstration of improved energy conversion efficiencies in thermoelectric materials will emphasize high temperature (1400°K) applications. Experimental testing of reactor and radiator heat pipes to provide reactor-converter interface requirements will also continue.

Research aimed at understanding the fundamental life-limiting mechanism in nickel-cadmium space batteries will be intensified, leading to the development of improved fabrication specifications. Development of the technology for high capacity energy storage required for future high power missions will place emphasis on fuel cell electrolyzers and high capacity battery cells. In addition, work on very high energy-density storage systems, based on lithium and sodium, will also continue.

	1980 <u>Actual</u>	1981		1982
		<u>Budget</u> <u>Estimate</u>	<u>Current</u> <u>Estimate</u>	<u>Budget</u> <u>Estimate</u>
		(Thousands of Dollars)		
Multidisciplinary research.....	2,644	2,800	2,700	5,200

OBJECTIVES AND STATUS:

The objective of the multidisciplinary research effort is to conduct novel, long-range, high-risk basic research investigations in engineering and physical sciences related to space. This research is conducted principally at universities through the Fund for Independent Research and the Physics and Chemistry Experiments in Space program. The

Fund for Independent Research supports basic research on many topics of fundamental importance, such as materials properties at high pressures, development of a free-electron laser, energy storage of atomic hydrogen, precision cryogenic maser (microwave laser) capable of testing the general theory of relativity, molecular binding between materials and ceramics, TV real-time imagery, crosslinking of polymeric membranes, optical constants of transition metals, and nonlinear interactions in superfluid dynamics. The Physics and Chemistry Experiments in Space program supports basic studies leading toward the development of experiments that need the unique characteristics of the space environment to make fundamental new discoveries about materials properties and processes. Some of the work supported includes complex liquid drops, mass transfer, surface driven convection, concentric rotating drops, granular soil behavior, superfluid helium measurements, and combustion.

CHANGES FROM FY 1981 BUDGET ESTIMATE:

The decrease of \$100,000 is part of the Congressional reduction to the FY 1981 NASA appropriation request.

BASIS OF FY 1982 ESTIMATE:

The research supported under this activity is to be increased substantially to broaden the study of innovative ideas that underlie and cut across the established disciplinary structure, including theoretical mathematics.

	1980 <u>Actual</u>	1981		1982
		<u>Budget Estimate</u> (Thousands of Dollars)	<u>Current Estimate</u>	<u>Budget Estimate</u>
Information systems research and technology.....	21,847	21,900	21,300	25,000

OBJECTIVES AND STATUS:

The objectives of the information systems research and technology program are to provide advanced sensor and instrumentation systems that will enhance the data acquisition capabilities of future Earth resources environmental observations, meteorological and space science missions, and to provide processing, reduction, and distribution to the user community in a timely and economical fashion. Linear array technology in the 2-15 micrometer region to obtain enhanced thermal images of terrestrial scenes is being developed. Quasi-optical submillimeter-receiver systems with a frequency capability of .5 to 2 terahertz (THz) are being developed for detection of the relative abundance of atmospheric trace gases. Laser-ranging systems are being developed to measure the geodynamics of the Earth's crust. Instrument pointing research, which aims at new concepts and components to provide accurate pointing and onboard video

landmark tracking capability, is being developed. Cooling system technology is being advanced in the area of ultralow temperature refrigeration systems for cooling sensors and experiments in space.

Design and test of a Ku-band modulator-exciter, which is capable of efficiently handling data rates as high as 2.5 gigabits/second (Gbps) was completed during FY 1980. Since this device uses microwave integrated circuit technology, it is smaller, weighs less, and requires less power than conventional modulator-exciters.

The dual frequency S- and Ku-band planar retrodirective antenna system which can accommodate the multigigabit data rates was completed during FY 1980. The antenna can handle up to 2 Gbps and provides the user spacecraft with the capability of communicating with the Tracking and Data Relay Satellite (TDRS), two or more spacecraft, or a spacecraft-to-ground station. This antenna is a prime candidate for Landsat-D.

The Feature Identification and Location Experiment (FILE) was successfully demonstrated in a brass-board configuration aboard a Comair 990 aircraft. The tests demonstrated that the FILE can provide versatile, automatic landmark tracking and feature recognition capability which is useful for Earth observations and planetary missions.

In a related technology area, a computer model which allows the end-to-end simulation of new data system concepts in terms of cost and performance was completed. In several months of operation more than twenty spacecraft have been simulated in a few hours of computer time, with selected performance parameters displayed.

CHANGES FROM FY 1981 BUDGET ESTIMATES:

The decrease of \$600,000 primarily reflects the Congressional reduction to the FY 1981 NASA appropriation request.

BASIS OF FY 1982 ESTIMATE:

During 1982, flight demonstrations will be performed on the 100-element indium antimonide linear-array charged-coupled infrared imaging device, the airborne mapping spectrometer (2-30 micrometers), the two-color laser altimeter, the infrared solid state self-scanning sensor system (8 to 12 and 1 to 4 micrometers) and the 1800 GHz-type receiver system. In addition, the FILE system will be flown again on the Comair 990 to determine if a detectable spectral signature exists between clouds and snow. The Annular Suspension and Pointing System (ASPS) will undergo additional integrated laboratory evaluation tests. Tests on laboratory prototypes for a 5-watt, long-life mechanical cooler will continue.

Advanced data and communications systems concepts will continue to be modeled and evaluated to provide improved end-to-end data system efficiency and effectiveness. During FY 1982, a flight qualified X-band transponder will be developed to meet the communication requirements of the International Solar Polar Mission. Work will be performed to

scale the Ku-band modulator-exciter up to 60 GHz. At this frequency, which is assigned to intersatellite links, this device will be capable of handling more than 4 Gbps of data. In the NASA End-to-End Data System program during N 1982, a prototype of the massively parallel processor will be developed, which will be capable of performing more than 10 billion additions per second and real-time analysis of Landsat type images. The modular spaceborne system which is designed to compute ancillary data such as orbit, altitude and time, will be demonstrated. This ancillary data allows the formulation in real-time of autonomous data packets. Work will be completed on the development of an integrated 10,000 billion bits ~~mass~~ memory and data base management system with data access time of 8 seconds and with accession of up to 50 Mbps. Also, preliminary designs for a real-time synthetic aperture radar processor will be completed.

	1980 <u>Actual</u>	1981		1982
		<u>Budget</u> <u>Estimate</u> (Thousands of Dollars)	<u>Current</u> <u>Estimate</u>	<u>Budget</u> <u>Estimate</u>
Spacecraft systems research and technology.. .. .	7,437	8,500	9,000	10,300

OBJECTIVES AND STATUS:

The objective of this program is to develop and demonstrate spacecraft systems technology for large space systems, advanced planetary spacecraft, and advanced Earth-orbiting spacecraft to enable current and future space missions. The program extends the accomplishments of the research and technology programs in the fundamental discipline areas to integrated activities such that the transfer of a complete capability is possible. Research and technology activities are conducted in areas where a multidisciplinary approach is essential to objective accomplishment. These activities share the common goal of eventual transfer and use of the technology in the NASA-developed spacecraft. This requires establishment of technical feasibility and acceptable levels of risk and cost.

The large space systems technology is the principal element in the spacecraft systems research and technology area and includes the development of large antennas for communications, radiometric, and astrophysics missions, large space platforms for science and application missions, and support activities for the design, fabrication, subsystem integration and control of large structures. In the antenna area, components for the Offset Wrap Rib, the 55-meter aperture, and the Hoop/Column, 50-meter aperture, will be fabricated and assembled for testing in FY 1982. The electrostatic membrane antenna concept has completed surface control and quality testing of a 16-foot diameter breadboard model. For platforms, a large deployable configuration has been tested in shear and torsion and has undergone deployment and assembly testing in the Neutral Buoyancy Facility.

The space-storable fluorine-hydrazine propulsion system is under development to provide the long-life, high performance required for advanced planetary missions. In FY 1981, final assembly and checkout will be completed prior to testing in N 1982.

Thruster characterization and life tests are being conducted for the 8-cm ion auxiliary propulsion system to establish operating limits, establish mission operations test plans and provide a data base for analysis of flight data.

The concept of utility-type distribution and management of electrical and thermal energy is being studied at an integrated system level. The effort builds on the discipline research and technology activities in power generation and storage and will seek to develop a system in the 100-kw region.

CHANGES FROM FY 1981 ESTIMATES:

The increase of \$500,000 reflects primarily the addition of \$1 million by Congress for large space structure research partially offset by the Congressional reduction to the FY 1981 NASA appropriation request.

BASIS OF FY 1982 ESTIMATE:

For the large space systems technology program, full-scale antenna and platform critical component tests will be conducted to define performance parameters. Also, additional antenna concepts will be selected for further development. In the antenna and platform areas, attitude control performance verification through simulation of non-linear models will be established and laboratory demonstrations will be conducted for advanced control concepts. Integrated analysis capability for large systems will be extended by incorporating RF and optical performance modules.

Ground and flight instrumentation and measurement strategies for validating the performance of large space systems will be developed. This activity will also include the development of the onboard data processing equipment which will translate the measurements into real-time control commands.

Technology readiness for the space-storable (fluorine-hydrazine) propulsion system will be demonstrated in FY 1982 by a systems test under simulated space conditions.

For the 8-cm ion auxiliary propulsion system thruster characterization tests will continue, Data Control and Interface Unit (DCIU) capabilities and limitations will be defined and activities to support mission operations will be initiated.

On the basis of the multi-100-kW thermal utility platform study completed in FY 1981, development of selected critical components for the main thermal bus and instrument module bus will be initiated. Studies to define thermal systems requirements for geosynchronous and planetary spacecraft will be conducted.

Efforts will be initiated to study and develop advanced spacecraft concepts and supporting spacecraft services. In the area of automation, definition of requirements for the automation of large power systems will be determined and will provide the precursor understanding for the follow-on development of fully autonomous, fault tolerant spacecraft systems. Studies and technology development activities focused toward understanding the sources and the effects of particulate and molecular contamination on spacecraft operational performance will be initiated.

	1980	1981		1982
	<u>Actual</u>	<u>Budget</u> <u>Estimate</u>	<u>Current</u> <u>Estimate</u>	<u>Budget</u> <u>Estimate</u>
		(Thousands of Dollars)		
Transportation systems research and technology.. .. .	10,725	8,000	6,800	8,700

OBJECTIVES AND STATUS:

The objectives of this program are: to identify the technology requirements for advanced transportation vehicles to satisfy national needs and then to integrate these requirements into a comprehensive plan that results in transfer-ready technology at the proper time; to develop the technology programs to satisfy these requirements; and, to support the development of the space transportation system in areas of technical competence. These objectives are accomplished through system level studies, analyses and requirement definition efforts, and system and discipline research and technology efforts requiring ground-based facilities, in-space hardware and instrumentation which permits the orbiter to be used as an advanced research vehicle.

During FY 1981, the aerodynamic, ground-based testing program to support the first Shuttle flight should be completed. A continuing test program is planned to support the analysis of the data resulting from the flight. Work on alternate configurations will continue.

On the first Shuttle flights, data obtained by instrumentation developed by the orbiter experiments program will permit calculation of the actual aerodynamic coefficients of the orbiter during its reentry. This data will support the effort to verify the performance of this advanced reentry vehicle, and its flight control and thermal protection systems. Additional instrumentation to expand this data base will reach flight-ready status in FY 1981 and will be delivered to the launch site for integration onto the Orbiter after the first and second flights.

CHANGES FROM FY 1981 BUDGET ESTIMATES:

The decrease of \$1.2 million primarily reflects the Ames Research Center accounting procedure change. The cost of the thermo-gasdynamics facilities are now being budgeted under the aerothermodynamics research and technology line item. An additional decrease was the result of the Congressional reduction to the FY 1981 NASA appropriation request.

BASIS OF FY 1982 ESTIMATE:

System analysis efforts will be conducted to define the scope and content of the technology programs needed to reduce the cost or improve the performance of future space transportation vehicles. Efforts to be initiated in FY 1982 will

address the automation of the recertification process for reusable vehicles, the use of aero-assist to capture transfer vehicles in low-Earth orbit, advanced energy generation and management systems for transportation vehicles, and advanced propulsion concepts for outer planet exploration. The ongoing effort to address the technology advances needed to support the evolutionary growth in the current space transportation system will be augmented to define in detail the identified high leverage areas.

During FY 1982, ground facilities will be used to conduct aerodynamic tests in support of the Shuttle orbital flight test program and to explore potential modification to the basic orbiter configuration. These tests will validate changes in the orbiter configuration or operation scenario to accommodate specific problems, increase operating margins, or permit incorporation of instrumentation developed in this program.

Three instrumentation package experiments which provide the basic aerodynamic data necessary for the orbiter to be used as a research vehicle will be flown on Orbiter 102 during FY 1982. The aerodynamic coefficient package, which was integrated into Orbiter 102 for OFT-1, will provide data during all early orbiter flights. The low and high altitude research air data systems will be integrated into Orbiter 102 after OFT-2, and the first flight will occur in late FY 1982 or early FY 1983.

Two instrumentation package experiments will be used to examine aerodynamic heating and, thus, the requirements of the thermal protection system and its operating limitations. The windward instrumentation package which is mounted in the C-141 Kuiper Aircraft Laboratory will be used during early orbiter flights. The leeside instrumentation package will be integrated into the tail pod on Orbiter 102 and the first flight will occur in late FY 1982.

The instrumentation packages to obtain dynamic, acoustic, and thermal data in the orbiter cargo bay will be delivered to the launch site in N 1982. One package will be mounted on the OSTA-1 pallet for flight on OFT-2. The second will arrive mounted on the OSS-1 pallet for flight on OFT-3 or 4.

N 1981 additions to the program will be well into the design and development phase. These include an orbiter altimeter package, two flight control experiments (direct activator control, and advanced autopilot software), a package to measure the effluence from solid rocket propulsion systems, and in-space hardware for an research and technology program in cryogenic fluid management. Packages which are candidates for inclusion in the program in FY 1982 include a titanium thermal protection test panel, two flight control experiments, two aerothermodynamic instrumentation packages, a structural temperature instrumentation package, and a composite test article. These efforts are in the definition phase in FY 1981.

All the data obtained by the basic orbiter flight instrumentation, the orbiter development flight instrumentation, and the special instrumentation developed in this program will be cataloged and filed for research purposes. This data base supports research programs which will address specific space transportation system problems or advanced generic vehicle technology.

BASIS OF FUNDING REQUIREMENTS:**SYSTEMS TECHNOLOGY PROGRAMS**

	1980	1981		1982	Page
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>	<u>No.</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>	
		(Thousands of Dollars)			
Space system studies.....	2,323	2,200	2,000	2,400	RD 10-19
Information systems technology.....	1,500	4,200	4,100	7,200	RD 10-20
Spacecraft systems technology.....	<u>6,947</u>	<u>1,400</u>	<u>1,400</u>	<u>3,600</u>	RD 10-21
Total.....	<u>10,770</u>	<u>7,800</u>	<u>7,500</u>	<u>13,200</u>	
Space Systems Studies.....	2,323	2,200	2,000	2,400	

OBJECTIVES AND STATUS:

The objectives of space systems studies are to identify and evaluate the technology requirements of advanced system candidates, to investigate future space mission alternatives, to assess the effects of technology advances, and to provide a data base to support technology program selection and program planning. Studies will continue to examine the development of future program technology needs, to determine the subsequent detailed technology requirements, and to consider alternative solutions for satisfying needs and requirements.

During FY 1981, studies continued towards the identification of needs and opportunities for planning the technology programs of spacecraft, information, and transportation systems and for improving and expanding the space systems technology model.

CHANGES FROM FY 1981 BUDGET ESTIMATES:

This decrease is a result primarily of the Congressional reduction to the FY 1981 NASA appropriation request.

BASIS OF FY 1982 ESTIMATE:

The FY 1982 efforts **will** continue to study the technology for spacecraft, information, and transportation systems. Analyses **will** be conducted to catalog and rank available, planned, and forecast technology from sources within and outside NASA. Continuing studies will rank technology options and develop strategies for the attainment of long-range goals through application to near-term missions. Special study emphasis will be given to key technology issues, such as computer sciences, autonomous spacecraft, automated launch and flight operations, cost-effective system scale growth, spacecraft support services, automated mission scheduling and decisionmaking techniques, Shuttle-derived vehicles, **aero-**assisted orbital transfer, and information systems for troposphere and stratosphere observations.

The space systems technology model will also be expanded to analyze the extensive data base of mission and technology capability forecasts. This will be used to identify technology gaps and voids and to generate planning and prioritization aids for research and technology program management.

	1980 <u>Actual</u>	1981		1982
		<u>Budget Estimate</u> (Thousands of Dollars)	<u>Current Estimate</u>	<u>Budget Estimate</u>
Information systems technology.....	1,500	4,200	4,100	7,200

OBJECTIVES AND STATUS:

The objective of this effort is to integrate advanced electronic devices or systems concepts developed in the research and technology base with supporting technology to demonstrate and validate improved performance, increased reliability and reduced costs for future information systems and to stimulate new systems concepts and services.

In 1980, the satellite communications technology program **was** initiated. The purpose of this activity **was** to develop the high risk satellite communications technology which opens new spectral bands, promotes conservation of the required electromagnetic spectrum and geostationary orbit slots and facilitates the development of innovative, low cost, satellite communications services to the public. Experimental development of 20 GHz Traveling Wave Tube (TWT) **was** initiated and design studies were conducted for 20 GHz TWT and multistage depressed collector. In the antenna area, design concepts for a near-field planar scanner system were developed. Basic computer programs required for calculation of far-field antenna patterns from near-field measurements were implemented. The design and fabrication of a 7-element cluster-of-elements feed with controllable phase and amplitude distribution **was** demonstrated at 20 GHz. In the solid state material and components area, work **was** initiated to define the laboratory measurements capabilities including facilities and equipment for network analysis, stripline fabrication, and surface characterization.

CHANGES FROM FY 1981 BUDGET ESTIMATES:

The decrease of \$100,000 reflects the Congressional reduction to the FY 1981 NASA appropriation request.

BASIS FOR FY 1982 ESTIMATES:

Research and technology efforts in the satellite communications technology program will cover basically two activities: 30/20 GHz communications program and land mobile satellite service. In each of these activities, the effort will continue on solid state power amplifiers suitable for single or multidevice amplifiers, modulators, and demodulators; new tube amplifier fast wave devices for shorter wavelength and higher power application; linear power amplifiers; antenna feeds; and new power processor devices for efficient energy transfer.

In FY 1982 work will begin on testing the 20 GHz transmit array. Antenna system development will begin. Circuit development for 30 GHz monolithic receiver module and monolithic microwave integrated circuit component development for multimode integrated structural, radio frequency, control and thermal effects model link of the 30/20 GHz and land mobile satellite service antennas will start. Also, tests designed to determine the feasibility of cooled feed array for 30 GHz cooled low-noise receiver will be started.

	1980 <u>Actual</u>	1981 <u>Budget</u> <u>Estimate</u>	1981 <u>Current</u> <u>Estimate</u>	1982 <u>Budget</u> <u>Estimate</u>
		(Thousands of Dollars)		
Spacecraft systems technology.....	6,947	1,400	1,400	3,600
Space Transportation Systems Operations..	(65)	(8,900)	(32)	(700)

OBJECTIVES AND STATUS:

The objective of this effort is to provide the capability to extend research and technology programs into the environment of space using the Shuttle, Spacelab, and free-flying vehicles. Research and technology programs are so extended when the unique space environment is essential to the progress of the effort, when an in-space test is cost-effective, or when an in-space verification will accelerate the utilization of advanced technology. This effort provides an effective means to demonstrate technology readiness so that the advanced technology capability can be used for important space missions at an acceptable cost and risk.

The activity includes the development, integration, and flight operations of experiments to be conducted in the Spacelab, the development of the Long Duration Exposure Facility (LDEF), the development and integration of experiments for the first LDEF mission, and a flight demonstration of an ion auxiliary propulsion system on a free-flying Air Force satellite.

The Spacelab experiments remaining in the program are assigned to early Spacelab missions. They are all being completed on schedules compatible with the integration requirements of their assigned missions. The thermal cannister experiment has been integrated to the Spacelab pallet awaiting launch in early FY 1982.

The LDEF is completed and in storage. The experiments are in various stages of development and fabrication, and some experiments have been placed in storage.

The 8-cm ion auxiliary engine flight demonstration on the USAF P80-1 spacecraft will provide the in-space demonstration of technology readiness.

BASIS OF FY 1982 ESTIMATE:

In FY 1982, the thermal cannister experiment will be launched and preliminary data analysis completed. The SEPS Solar Array and the Solar Cell Calibration experiments will be integrated into the Shuttle for an early FY 1983 launch. Other experiments will have been fabricated, and, in most cases, integrated into flight packages or placed in storage awaiting future integration and flight.

The LDEF will be removed from storage and prepared for shipping. Experiments will be tested and further prepared for integration into the LDEF in anticipation of an early FY 1984 launch date.

Flight hardware for the experimental test of the 8-cm ion auxiliary propulsion system will be completed and qualification tested in preparation for integration with the USAF P80-1 spacecraft.

BASIS OF FUNDING REQUIREMENTS:

STANDARDS AND PRACTICES

	<u>1980 Actual</u>	<u>1981 Budget Estimate</u> (Thousands of Dollars)	<u>1981 Current Estimate</u>	<u>1981 Budget Estimate</u>
Standards and practices.. .. .	5,000	2,100	2,100	3,000

OBJECTIVES AND STATUS:

The objective of the standards and practices program is to provide an agency focal point for all program assessment functions relative to program assurance, safety, standards, practices and special project activities to insure mission integrity. This includes responsibility for overall review of the technical execution of all NASA programs to assure that the development efforts and mission operations are being planned and conducted on a sound engineering basis with proper programmatic controls. Specially, the objectives are to maintain an overview of the technical execution of NASA programs; address technical problems highlighted in reviews; review program plans, project execution, conduct surveys and special investigations related to program execution, reliability, quality assurance and systems safety. Develop policies; monitor compliance; issue experience bulletins on program assurance-related issues; develop handbooks and guidelines governing reliability, quality assurance, software, safety and other practices; participate with interagency and industry groups in activities fostering better cooperation on programs and issues of mutual interest.

During FY 1980, the major effort was the initiation and substantial completion of an independent review and assessment of the adequacy of the Space Transportation System-1 (STS-1) Flight Verification/Certification program. The assessment was divided into thirteen main areas: propulsion, integrated vehicle loads; orbiter loads; aero and thermal analysis; thermal protection system; flight control hydraulics system and associated electronics; launch and ascent guidance, navigation and control; entry and landing guidance, navigation and control; landing/deceleration system and miscellaneous critical mechanisms; environmental control and life support systems and crew equipment; separation systems; electrical power distribution and control; and ground systems. A "cognizant engineer" was assigned responsibility for each of these areas. Support was provided by technical experts from within and outside NASA, and through contracts with organizations familiar with the technical areas under review.

The standard equipment development program ~~was~~ completed and cognizance for the items in inventory transferred to the flight projects using the equipment. The computer-based data bank listing of presently flight-qualified NASA equipment and similar equipment available from industry ~~was~~ initiated with a pilot program. The objective is to encourage users to consider use or modification of these items before beginning independent designs. A NASA/DOD information exchange program to identify spacecraft equipment malfunctions of subsystems/components used by both organizations in a timely manner began development. Increasing emphasis ~~was~~ directed at integrated circuit system assurance; systems safety; standard and flight-qualified parts quality; environmental engineering standards; workmanship guidelines; and software assurance.

BASIS OF FY 1982 ESTIMATE:

The FY 1982 program will continue efforts to categorize significant parameters for predicting product quality, reliability and performance in expected radiation environments and identify the development risks of spacecraft components, systems and software. Increased emphasis will be directed at identifying test methods and procedures which promise to improve the correlation between ground test results and experience in orbit. This is becoming increasingly important because of the greater complexity and longevity of spacecraft under development. The Office of the Chief Engineer will **also** provide continuing support to identify corrective actions that can be taken to overcome on-orbit anomalies in integrated circuit subsystems due to cosmic ray impingement on spacecraft components, and will explore the merit of selected engineering validation projects to accelerate technology transfer from feasibility demonstration to use in specific space programs. Projects to enhance reliability, quality assurance and program safety, as well as the Available Flight-Qualified Equipment Listing, NASA/DOD Common User Exchange, and preparation of engineering standards and guidelines will be continued. Special taskings from the Administrator or Deputy Administrator, such as the STS-1 Flight Verification/Certification program review and assessment, will continue to be major responsibilities of the Office of the Chief Engineer.

ENERGY
TECHNOLOGY



RESEARCH AND DEVELOPMENT
FISCAL YEAR 1982 ESTIMATES
BUDGET SUMMARY

OFFICE OF NAUTICS AND SPACE TECHNOLOGY

ENERGY TECHNOLOGY

SUMMARY OF RESOURCES REQUIREMENTS

	1980 <u>Actual</u>	1981 <u>Budget Estimate</u> (Thousands of Dollars)	Current <u>Estimate</u>	1982 <u>Budget Estimate</u>
Energy Technology.....	<u>3,000</u>	<u>4,000</u>	<u>3,900</u>	<u>4,400</u>
<u>Distribution of Program Amount by Installation:</u>				
Johnson Space Center.....	---	150	225	225
Kennedy Space Center.....	20	---	80	120
Marshall Space Flight Center.....	995	1,250	1,305	1,450
National Space Technology Laboratories..	---	---	50	100
Jet Propulsion Laboratory.....	926	1,750	1,515	1,780
Lewis Research Center.....	983	700	700	300
Headquarters.....	<u>76</u>	<u>150</u>	<u>25</u>	<u>425</u>
Total.....	<u>3,000</u>	<u>4,000</u>	<u>3,900</u>	<u>4,400</u>

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1982 ESTIMATES

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

ENERGY TECHNOLOGY

PROGRAM OBJECTIVES AND JUSTIFICATION:

The major goal of the energy technology program is to apply NASA aeronautics and space technologies, experience, and facilities to the energy research and development needs of the Nation; and to understand, evaluate, and define how NASA capabilities can be applied to exploit the unique characteristics of the space environment to help solve energy-related problems on Earth. These objectives are accomplished through the initiation of NASA-funded exploratory programs in energy technology areas that have close affinities to established NASA expertise; and the subsequent conversion of these efforts into reimbursable programs that exploit unique NASA technical capabilities.

Over the past several years, the Department of Energy, and other agencies, have looked to NASA to provide technical expertise for analyses of new energy problems, and to recommend solutions to these problems. These independent analyses will be continued to assure that this capability is retained.

As a result of the NASA-funded energy research and technology efforts conducted to date, NASA is now a major contributor towards the successful development of technologies in wind energy systems, solar heating and cooling, photovoltaic conversion, energy storage, advanced ground propulsion, and fossil fuel power generation. In addition, analyses conducted to date support continued study into the feasibility of utilizing the unique space environment to provide energy (Satellite Power System) and to dispose of nuclear waste.

CHANGES FROM FY 1981 BUDGET EST MATE:

The reduction of \$100,000 in the FY 1981 estimate is the result of the general Congressional reduction in the NASA appropriation request.

BASIS OF FY 1982 ESTIMATE:

FY 1982 funding at the \$4.4 million level will provide for the continuation of selected, critical technology investigations in such areas as: solar energy applications, bioenergy, electric utility systems, advanced coal conversion and power generation systems, and automotive transportation systems; and will permit NASA to submit proposals on the more promising of these potential energy concepts to outside agencies for reimbursable support.

TRACKING AND
DATA ACQUISITION

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1982 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE TRACKING AND DATA SYSTEMS

TRACKING AND DATA ACQUISITION PROGRAM

SUMMARY OF REQUIREMENTS

	1980	1981		1982	Page
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>	<u>No.</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>	
		(Thousands of Dollars)			
Operations.....	264,400	270,000	267,100	309,800	RD 12-4
Systems implementation.....	57,100	67,700	62,700	112,900	RD 12-14
Advanced systems.....	10,600	11,300	11,300	12,500	RD 12-23
Total.....	<u>332,100</u>	<u>349,000</u>	<u>341,100</u>	<u>435,200</u>	
<u>Distribution of Program Amounts by Installation:</u>					
Marshall Space Flight Center	555	---	200	200	
Goddard Space Flight Center..	231,460	243,100	237,300	294,300	
Jet Propulsion Laboratory.....	70,375	74,000	75,600	103,000	
Wallops Flight Center.....	6,580	6,800	5,950	11,300	
Dryden Flight Research Center..	3,050	3,600	3,050	3,500	
Headquarters.....	20,080	21,500	19,000	22,900	
Total.....	<u>332,100</u>	<u>349,000</u>	<u>341,100</u>	<u>435,200</u>	

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1982 ESTIMATES

USE OF SPACE TRACKING AND DATA SYSTEMS

TRACKING AND DATA ACQUISITION PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The purpose of this program is to provide vital tracking, command, telemetry and data acquisition support to meet the requirements of all NASA flight projects. In addition to NASA flight projects, support is provided, as mutually agreed, for projects of the Department of Defense, other Government agencies, commercial firms, and other countries and international organizations engaged in space research endeavors.

Support is provided for: sounding rockets, research aircraft, Earth orbital and suborbital missions, planetary spacecraft, and deep space probes. It also includes the support of all phases of the Space Shuttle flight program. The various types of support provided include: (a) tracking to determine the position and trajectory of vehicles in space; (b) acquisition of scientific and space applications data from on-board experiments and sensors; (c) acquisition of engineering data on the performance of spacecraft and launch vehicle systems; (d) transmission of commands from ground stations to spacecraft; (e) communication with astronauts; (f) communication of information between the various ground facilities and central control centers; (g) processing of data acquired from the launch vehicles and spacecraft; (h) reception of TV from space vehicles. Such support is essential for achieving the scientific objectives of all flight missions, for executing the critical decisions which must be made to assure the success of these flight missions, and, in the case of Shuttle missions, to insure the safety of the crew. Tracking and acquisition of data for the spaceflight projects is accomplished by the use of a worldwide network of NASA ground stations. These facilities are interconnected by ground communications lines, undersea cables, and communications satellite circuits which are leased from communications carriers, both domestic and foreign. This interconnection provides the communications capability needed between spacecraft and the control centers from which the flights are directed.

To meet the support requirements levied by the wide variety and large number of flight projects, NASA has established two networks to meet the needs of the two classes of NASA flight missions. These are the Spaceflight Tracking and Data Network (STDN), which supports Earth orbital missions and the Deep Space Network (DSN), which supports planetary and interplanetary flight missions.

Computation facilities are maintained to provide real-time information for mission control and to process into meaningful form the large amounts of scientific, applications, and engineering data which are collected from flight projects. In addition, instrumentation facilities are provided for support of sounding rocket launchings and flight testing of aeronautical research aircraft.

In future years, the operation of the Tracking and Data Relay Satellite System (TDRSS) will be an important element of the NASA space program. This system will support nearly all Earth orbital spacecraft missions and will greatly improve NASA's Earth orbital tracking and data acquisition capabilities. NASA will obtain TDRSS services via a service contract with Space Communications Company who will develop, own and operate the system. Service is planned to be initiated in PY 1983.

With the advent of TDRSS services, several of the STDN tracking stations will be closed in 1984. Planning is also underway to consolidate the remaining core STDN stations with those of the DSN under the management of the Jet Propulsion Laboratory (JPL). The consolidation is keyed to providing a single network in the mid-1980s to support synchronous, highly elliptical, and planetary missions while reducing operations and maintenance costs.

The research and development (R&D) appropriation provides funds for: (a) the operations and maintenance of the worldwide facilities; (b) the engineering and procurement of equipment to sustain and modify the network systems to support continuing, new, and changing flight project requirements; and (c) the development of advanced tracking and data acquisition systems and the investigation of advanced tracking and data acquisition techniques.

CHANGES FROM FY 1981 BUDGET ESTIMATE:

The current estimate for N 1981 is \$7.9 million below the budget estimate. This reflects the general Congressional reduction of the FY 1981 appropriation which has resulted in the elimination of telemetry links at two stations and an operating shift at another; the deferral of a significant portion of the mission control center capability intended to improve the utilization and efficiency of the general purpose control center systems; a rephasing of the funding for the procurement of the Landsat-D transportable ground station and delay of its associated communication terminal; and deferral of Wallops radar component replacement.

This reduction has impacted the level and reliability of current support to ongoing satellites and has added further risk to timely completion of preparation for upcoming missions and tasks.

OPERATIONS

BASIS OF FY 1982 FUNDING REQUIREMENTS:

Funds requested for operations provide for the procurement of manpower and services needed to operate the worldwide network of NASA ground facilities including tracking stations, mission control centers, computation and data processing facilities, support instrumentation for sounding rocket and aeronautics programs and to provide the communications required in support of NASA programs. The FY 1982 funding request provides support to approximately 50 automated Earth orbiting and planetary missions. The funds requested for operations also provide for support of space shuttle flights and for the pre-launch support activity required for upcoming approved missions. The increase in FY 1982 is primarily due to escalation and support requirements for upcoming approved programs such as Shuttle, Landsat-D, preparation for TDRSS service recovery and logistics support, and for the consolidation and restructuring of contractual effort at the Goddard Space Flight Center (GSFC).

	1980	1981		1982	Page
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>	<u>No.</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>	
		(Thousands of Dollars)			
Spaceflight tracking and data network.....	130,530	133,300	130,400	150,500	RD 12-5
Deep space network.....	58,020	54,100	56,000	64,600	RD 12-7
Aeronautics and sounding rocket support.....	4,830	5,500	5,500	6,800	RD 12-9
Communications Operations	35,130	39,300	37,400	41,200	RD 12-10
Data processing	<u>35,890</u>	<u>37,800</u>	<u>37,800</u>	<u>46,700</u>	RD 12-11
Total.....	<u><u>264,400</u></u>	<u><u>270,000</u></u>	<u><u>267,100</u></u>	<u><u>309,800</u></u>	

	1980	1981		1982
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimte</u>	<u>Estimate</u>	<u>Estimte</u>
		(Thousands of Dollars)		
Spaceflight tracking and data network operations.....	130,530	133,300	130,400	150,500

OBJECTIVES AND STATUS:

The primary function of the Spaceflight Tracking and Data Network System (STDN) is to support all NASA Earth orbital spaceflight missions, including the Space Shuttle. The majority of these missions have near-Earth orbits; however, the network also supports selected missions through lunar distances and beyond, such as the International Sun-Earth Explorer missions. In addition, the network provides launch support to NASA automated planetary missions, as well as spaceflight missions of other nations, commercial firms, the Department of Defense, and other United States government agencies. Accordingly, the network must be responsive to the requirements of a large number and wide variety of flight projects from launch through completion of the flight project objectives. In many instances, the period of network support required by flight projects continues for several years.

The STDN presently consists of twelve geographically dispersed ground stations. A network control center and mission control center complex are located at the GSFC which has the field center management responsibility for the network. Separate contracts exist for network logistic support, the maintenance and operation of the mission control center complex and for operation of the network control center.

These global facilities have the capability to electronically track the spacecraft, send commands for spacecraft and experiment control purposes, receive engineering and scientific data from the spacecraft, and in the case of manned flights, maintain voice communications for crew safety and other project related purposes.

In addition to the operational facility at the GSFC, eleven land stations are located at Fairbanks, Alaska; Goldstone, California; Merritt Island, Florida; Kauai, Hawaii; Guam; Ascension Island; Canberra, Australia; Bermuda; Santiago, Chile; Quito, Ecuador; and Madrid, Spain. Separate operations contracts exist for the Australian, Chilean, and Spanish sites with the balance of network operations and maintenance covered in single procurement effort. A transportable station is located near NASA's Dryden Flight Research Center (DFRC), California, for support of the Shuttle program. Additional small transportable stations are located at New Smyrna Beach, Florida, and Tula Peak, New Mexico, for support of the early Shuttle missions. An engineering test and network system training facility at GSFC is also maintained and operated as part of the STDN.

The SIDN has provided support to approximately forty-five automated applications and space science spacecraft during the past year. Examples of significant missions being supported include Landsat-2 and -3, three Applications Technology Satellites (ATS-1, -3, and -5); Solar Maximum Mission; two High Energy Astronomy Observatories (HEAO-2 and -3); Atmosphere Explorer (AE-5); Nimbus-5 -6, and -7; the International Sun-Earth Explorers (ISEE-1, -2, and -3); and the International Ultraviolet Explorer (IUV). Upcoming missions to be supported by the network include the Space Telescope, the Dynamics Explorer mission, the Gamma Ray Observatory, and the Space Shuttle orbital flight tests. The overall spacecraft support workload of the SIDN is projected to average approximately forty spacecraft during 1982.

CHANGES FROM FY 1981 BUDGET ESTIMATE:

The decrease of \$2.9 million as a result of the general reduction to FY 1981 appropriations will result in the closure of telemetry links at Alaska and the Network Test and Training Facility, a one shift reduction at the station in Hawaii, and the consolidation of mission control activity for HEAO-2 and -3. Support reductions were also made at other control facilities. The closure and shift reduction will impact support being given to several flight projects.

BASIS OF FY 1982 ESTIMATE:

The FY 1982 funding requirements for the SIDN operations provide for the maintenance and operation of the network and control center facilities, including staffing and training activities in preparation for the initiation of TDRSS services in FY 1983. Also provided for are the related logistics, network planning, scheduling, documentation, and computer programming costs associated with the around-the-clock operation of the network.

The request in FY 1982 is based upon a substantial support workload requirement; in particular, support of the high priority Shuttle orbital flight tests including recently identified air to ground voice requirements, preparation and initial operation of the Landsat-D transportable ground station, recovery and logistics support backlog from the FY 1981 constrained level, and the consolidation and restructuring of support contracts at the Goddard Space Flight Center.

	1980	1981		1982
	<u>Actual</u>	<u>Budget</u> <u>Estimate</u>	<u>Current</u> <u>Estimate</u>	<u>Budget</u> <u>Estimate</u>
		(Thousands of Dollars)		
Deep space network operations.....	58,020	54,100	56,000	64,600

OBJECTIVES AND STATUS:

The primary function of the Deep Space Network (DSN) is to support planetary and interplanetary spaceflight missions. The DSN provides the vital two-way communication link by which the distant spacecraft are controlled and scientific data are acquired. As the planetary missions become more complex and flight distances continue to increase, this network requires systems software and operational techniques that push the state-of-the-art in telecommunications.

The DSN stations are located at Goldstone, California; Canberra, Australia; and Madrid, Spain. The stations consist of one ~~64-meter~~, one ~~26-meter~~, and one 34-meter diameter antenna at each location. The three locations are approximately 120 degrees apart in longitude and permit continuous viewing of the planetary spacecraft. A centralized control center for the network is located at the Jet Propulsion Laboratory (JPL) in Pasadena, California. JPL has field management responsibility ~~for~~ the network. Separate contracts exist for the operation of the Australian, Spanish, and Goldstone sites. The contract for the Goldstone station also includes network support activities and operation of the network control center at the JPL.

The current workload in the DSN consists of seven ongoing Pioneer spacecraft (Pioneer 6-11 and Pioneer Venus), the Viking 1 ~~Mars~~ Lander, one Helios mission, and two Voyager spacecraft. Support of these missions will continue during FY 1982.

The ~~DSN~~ provided excellent support to the recent Voyager I encounter of Saturn. The Voyager I Saturn encounter returned over 17 thousand images through the ~~DSN~~ utilizing arrayed antenna technique which had previously been tested by the Voyager flyby of Jupiter and Pioneer 11 flyby of Saturn. Plans for Voyager II include a Saturn encounter in August of 1981.

Of the older Pioneer spacecraft, Pioneer 10 is over 3.3 billion kilometers from Earth and is proceeding on a path that will take ~~it~~ beyond the solar system. Pioneer 10 continues to be the most distant man-made object communicated with and each time data is received by the DSN, a new communications record is established.

The Pioneer 11 spacecraft, some 1.5 billion kilometers from Earth, is being tracked as it proceeds on a path taking it out of the solar system. The Pioneer 6-9 spacecraft are provided support during solar conjunctions. The two Helios missions are continuing their orbit about the Sun and the Viking lander continues to gather science data from Mars.

The DSN facilities are also used on a non-interference basis for ground-based measurements in support of experiments in planetary radar mapping and in the field of radio astronomy. The ultrasensitive network antennas are being used in an attempt to learn more about the mysterious pulsar high energy sources, quasars, and other interstellar phenomena.

In addition to the activities associated with the network modifications and support cited above, the DSN workload includes preparation for several future missions including the two International Solar Polar Spacecraft (North and South), and the two Galileo spacecraft (orbiter and probe). This support preparation involves thorough and complex testing, training, and engineering (both hardware and software). The activities must be carried out simultaneously with the extensive and continuous ongoing Deep Space Network support workload, and must be done in such a way as to cause minimum disruption to ongoing flight project support.

CHANGES FROM FY 1981 BUDGET E

The increase of \$1.9 million in the FY 1981 level is due to higher than estimated escalation at the overseas tracking stations and at the Jet Propulsion Laboratory, and for specialized support for the recent Voyager Saturn encounter.

BASIS OF FY 1982 ESTIMATE:

The DSN operations funding provides for the maintenance and operation of the network facilities, control center, and the support and engineering effort associated with the operation of the network. While the JPL has management responsibility for the network, there are separate contracts established under international agreements for operations of the tracking facilities in Spain and Australia. The funds requested for FY 1982 are based upon the ongoing workload, including the Voyager missions, the Pioneer 6-11 missions, the Pioneer-Venus extended mission, and the Viking Lander extended mission. The increase between N 1981 and FY 1982 is due principally to escalation, particularly at the overseas station locations.

	1980	1981		1982
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
	<u>1</u>	<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of Dollars)		
Aeronautics and sounding rocket support operations.....	4,830	5,500	5,500	6,800

OBJECTIVES AND STATUS:

Fixed and mobile instrumentation systems are maintained and operated to support sounding rocket, balloon, spacecraft, and aeronautical programs conducted by the Wallops Flight Center (WFC) and the aeronautical flight research programs of the Dryden Flight Research Center (DFRC). These instrumentation systems include radar, telemetry, data processing, data handling, and communications systems as well as special purpose optical equipment.

The sounding rocket program continues to be an active program with over 285 launches in CY 1980, the majority of which were conducted at WFC. In addition, there were thirty balloon flights during the same period. This effort tends to remain more or less constant from year to year and no dramatic changes are anticipated in the near future. At the WFC, the aeronautical programs are primarily related to investigation of aircraft handling characteristics, advanced control and display concepts, spin and stall tests, terminal area guidance and traffic control systems, and noise studies. Over 200 missions were conducted during 1980. In addition to support of sounding rocket, balloon, and aeronautical programs, instrumentation at WFC will be utilized to support the Shuttle orbital flight tests (OFT).

DFRC operates the aeronautical test range which provides radar, telemetry and communications support for the performance of aircraft research and development programs for both NASA and the Air Force. A variety of programs are conducted involving high performance aircraft, such as the F-111, F-14, F-15, F-104, F-8, and research vehicles such as the Tilt Rotor Research Aircraft, Highly Maneuverable Aircraft Technology (HiMAT), Drones for Aerodynamic and Structural Testing (DAST), and other remotely controlled craft. DFRC is the prime landing site for STS-1 and tracking and data acquisition support of the Shuttle OFT is planned at DFRC during FY 1981 and FY 1982. Over 250 aeronautical research missions were supported at DFRC during CY 1980.

BASIS OF FY 1982 ESTIMATE:

The FY 1982 funding requirements provide engineering and technical services for maintenance and operation of fixed and mobile radar, telemetry communications, data handling and processing equipment and facilities to support the ongoing sounding rocket and balloon programs and the aeronautical research activities. The increase in FY 1982 over FY 1981 is due to escalation and software program conversion associated with the new impact prediction system being procured for Wallops Flight Center (WFC).

	1980	1981		1982
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of Dollars)		
Communications operations	35,130	39,300	37,400	41,200

OBJECTIVES AND STATUS:

NASA's global communications network (NASCOM), interconnects with the tracking and data acquisition facilities by means of leased voice band and data circuits support to all flight projects. NASCOM also links such facilities as launch areas, test sites, and mission control centers. GSFC operates the NASCOM and serves as its major switching control point. In the interest of economy, reliability, and full utilization of trunk circuitry, subswitching centers have been established at key domestic and Overseas locations.

The NASA flight projects require the transfer of data between the mission control centers and the tracking sites because of the need for real-time control of the spacecraft and on-board experiments. In addition, there is a requirement to provide experiment data expeditiously to the users for analysis.

In order to meet high data transfer rate requirements, NASA has made and continues to make use of digital techniques in providing communications support. The availability of this technology allows for a greater amount of data to be sent Over conventional communication circuits. Also, circuits capable of transferring data at increasingly higher rates continue to become available from the common carriers at reasonable costs. Consequently, the techniques of sending data directly from a spacecraft, through a tracking station without manipulation, to a mission or project control center have become economically attractive and are used extensively in NASCOM. This approach, referred to in the communications field as a "bent pipe" mode, simplifies the data handling systems at the tracking stations, thereby minimizing the operation and maintenance activities at those locations.

CHANGES FROM FY 1981 BUDGET ESTIMATE:

The decrease in FY 1981 funding level resulted from a rate reduction for circuits to Australia, and the impact of the Congressional reduction which will delay implementing wideband circuits to Australia for Shuttle, and delay bringing up the wideband circuits for the TDRSS.

BASIS OF FY 1982 ESTIMATE:

The FY 1982 funding requirements for communications operations will provide for the circuits and service required to operate and maintain the NASCOM. The international communications satellites and cables will continue to be used for extension of digital wideband services to all the overseas tracking stations. The domestic satellite systems and terrestrial networks will continue to service the continental United States stations. These services will provide for real-time transfer of data for all ongoing flight programs. The major increases in FY 1982 are due to the activation and test of an up to 50 MBS digital wideband service from the TDRSS facility at White Sands to both the Goddard Space Flight Center (GSFC) and Johnson Space Center (JSC) in support of Spacelab and Landsat-D high data rate requirements, the activation of a Landsat-D communications link from the Indian Ocean area, and cost escalation.

	1980 <u>Actual</u>	1981 <u>Budget</u> <u>Estimate</u> (Thousands of Dollars)	1981 <u>Current</u> <u>Estimate</u>	1982 <u>Budget</u> <u>Estimate</u>
Data processing operations	35,890	37,800	37,800	46,700

OBJECTIVES AND STATUS:

Information received in the form of tracking and telemetry data from the various spacecraft must be processed into a usable form before transfer to control centers and experimenters. This transformation and computation process is performed as part of the data processing function and applies to a wide variety of programs, ranging from the small Explorer satellites to large and complex solar/astronomical observatories and the Landsat satellites.

Tracking data is processed to provide orbital information which is used to compute spacecraft position. This is essential for the real-time control of spacecraft, for determining when the spacecraft will be passing over the stations so data can be acquired, and for providing precise information that can be used by the scientific experimenters to determine where in the trajectory of the spacecraft the scientific measurements were made. Telemetry data must be processed to: (a) separate the information obtained from various scientific experiments aboard the spacecraft; (b) consolidate information for each experiment; (c) determine spacecraft attitude; and (d) correlate these measurements with the position data. Processed data is the primary product of the spacecraft missions and it is through reduction and analysis of this data by the experimenters that the planned objectives are achieved.

In addition to the actual processing of the data, upcoming projects require extensive prelaunch orbit analysis including spacecraft position and attitude predictions. Analyses are also required to develop operational sequences and

procedures to be used during the actual operation of these complex spacecraft. Examples of these activities are: (1) the final checkout and acceptance of the operational orbit support software for STS-1 launch in early 1981 and (2) the analysis and development of the operational attitude software for support of the Dynamic Explorer mission to be launched in late 1981.

As part of the data processing activities, there is a great deal of effort required to process original or raw information received from the on-board experiments. Two facilities, the Image Processing Facility (IPF) and the Telemetry On-Line Processing System (TELOPS) have been established at the Goddard Space Flight Center to process different types of raw experimental data.

The IPF, initially established to handle imagery data from the Earth Resources Technology Satellite (Landsat-1), now supports the second and third Landsat spacecraft. These spacecraft are supported with a new all digital system using computer compatible tapes which reduce the time required to provide data to users. The operational requirement for this facility is expected to continue through the next several years for support of the currently operational or approved programs.

The Telemetry Processing Facility which handles the conventional, nonimagery data was reconfigured in FY 1978 as the Telemetry On-Line Processing System. This reconfiguration resulted in a change from a tape-oriented system to an automated on-line electronic mass storage system. TELOPS receives satellite data in digital form from the tracking stations via NASCOM communication lines and is able to electronically store large volumes of telemetry data, thus eliminating most of the tape and tape handling operations. Maintenance and operations support for the image and non-image data processing facilities is provided by a single contractor. There are two other contracts under which software development and maintenance is provided for new systems along with software for orbit computation, attitude determination, flight maneuvers, scheduling, and mission simulation support.

BASIS OF FY 1982 ESTIMATE:

The FY 1982 budget request includes funds to operate the IPF and the TELOPS to process data from currently orbiting satellites, and from satellites scheduled to be launched during the period. The requirements for the acquisition and processing of data from the older satellites are under continuing review as support for older missions is terminated or curtailed as mission objectives are achieved or when the experiment data is no longer useful or cost effective to acquire and process.

Software development activities are continuing or will be initiated in support of upcoming space science and applications missions such as Space Telescope, Cosmic Background Explorer and the Gamma Ray Observatory. These activities cover spacecraft orbit and attitude control software and related data processing activities which require FY 1982 funding. Software effort is also required to develop the necessary programs to accommodate spacecraft which will operate the Tracking and Data Relay Satellite System.

Funding increases are required to continue the consolidation and restructure of the support contracts at GSFC for the activities carried out under this program. There is also a requirement in FY 1982 for parallel operation of computer systems that are being replaced while the new equipment **is** being tested and accepted. Additionally, funds are included for improvement to the operational reliability of the Image Processing Facility.

SYSTEMS IMPLEMENTA

BASIS OF FY 1982 FUNDING REQUIREMENTS:

The objectives of the NASA tracking and data systems implementation program are to maintain the existing ground support capability at a high level of proficiency and reliability in order to meet the aggregate support needs of the many and varied space missions, and to provide augmentation to this capability, as necessary, to meet the special requirements of individual flight projects. These ground support systems consist of the tracking and communications networks, control centers, data processing facilities and aeronautics and sounding rocket instrumentation. The systems implementation program encompasses the engineering, design and procurement of the necessary equipment, subsystems, and systems in response to the requirements of the various flight missions and other research projects. It also includes related documentation and basic software, the purchase of large module spares, and the acceptance testing, integration and checkout of equipment.

FY 1982 funding is needed to maintain the operational proficiency and reliability of network systems through the replacement of obsolete and worn out equipment. Modification and augmentation of existing systems are also necessary to maintain compatibility with changes in associated on-board spacecraft communications systems and to improve the utilization and efficiency of network systems. In addition, FY 1982 funds are required to continue the implementation of new capabilities for upcoming missions, including the International Solar Polar Mission, Galileo, Space Telescope, Gamma Ray Observatory, Shuttle, Spacelab, and the Venus Orbiting Imaging Radar mission. Implementation activities continue at the network control center and the NASA ground terminal at White Sands, New Mexico, and with other TDRSS related systems in preparation for the initiation of TDRSS service in FY 1983.

Funds are included as part of a phased program for the consolidation of the remaining SIND core stations with the DSN stations and for the augmentation necessary to provide an imaging capability for the Voyager Uranus encounter in January 1986.

	1980	1981		1982	Page
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>	<u>No.</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>	
		(Thousands of Dollars)			
Spaceflight tracking and data network.. .. .	19,320	22,600	20,700	25,100	RD 12-15
Deep space network.....	15,000	23,100	23,100	43,600	RD 12-17
Aeronautics and sounding rocket support.. .. .	3,850	4,100	3,500	8,000	RD 12-19
Communications systems implementation.....	5,030	5,600	3,100	6,900	RD 12-20
Data processing.....	<u>13,900</u>	<u>12,300</u>	<u>12,300</u>	<u>29,300</u>	RD 12-21
Total.....	<u>57,100</u>	<u>67,700</u>	<u>62,700</u>	<u>112,900</u>	
					RD 12-14

	1980	1981		1982
	<u>Actual</u>	<u>Budget</u>	<u>Current</u>	<u>Budget</u>
		<u>Estimate</u>	<u>Estimate</u>	<u>Estimate</u>
		(Thousands of Dollars)		
Spaceflight tracking and data network systems implementation.....	19,320	22,600	20,700	25,100

OBJECTIVES AND STATUS:

The spaceflight tracking and data network systems implementation program encompasses the procurement and implementation of systems and services to sustain network facilities and equipment to insure reliable support of ongoing scientific and applications satellite missions, to provide the necessary network and control center capabilities to perform the required control, tracking, command, and data acquisition functions in support of all NASA Earth orbital missions, and to meet new support requirements for spacecraft to be launched in the near future. Implementation of these capabilities is vital to the success of NASA's spaceflight missions.

Employing systems implemented in past years, the network is currently supporting many missions with highly complex requirements for tracking, data acquisition, command and control. Network and control center systems are in the final stages of implementation and test for upcoming new missions such as the Space Shuttle orbital flight test and Dynamic Explorers A and B. Plans and procurement are also underway to meet support requirements for future missions such as the Space Shuttle operational flights, Spacelab, Landsat-D, and the Space Telescope.

CHANGES FROM FY 1981 BUDGET ESTIMATE:

The decrease of \$1.9M is due to the Congressional reduction in FY 1981 resulting in the partial deferral to FY 1982 of the reconfiguration effort for improving the utilization of control center resources and rephasing of the funding for procurement of the Landsat-D transportable ground station.

BASIS OF FY 1982 ESTIMATE:

Equipment modifications are required in the network and control centers in FY 1982 to maintain the required level of proficiency to support a diverse and demanding workload and to assure the reliability of the major systems. Accordingly, funds are required to replace portions of aging systems, for equipment modifications to correct operational deficiencies, and for equipment to be used in operational control of the network. The funds requested also provide for procurement of major subsystem spares, for the provision and modification of test equipment, and for minor equipment modifications resulting from changes in support requirements from one mission to the next.

Funds are requested to continue the implementation activities at the new network control center (NCC) at GSFC. The major hardware system **has** been delivered and installed. The primary focus during FY 1982 will be to complete software for the system. When fully implemented the NCC will manage the interface with the TDRSS ground terminal, schedule TDRSS services for a variety of users, configure the ground terminal to provide scheduled user service, conduct network and user readiness and compatibility testing, and isolate component failures.

In addition, funds are requested to continue implementation of NASA systems associated with TDRSS and the related support activities and services necessary to prepare for an operational TDRSS. Installation, integration and testing of the TDRSS-related bilateration tracking system, mobile compatibility test vans, and the NASA portion of the TDRSS ground terminal will be completed. Supporting activities to assist the TDRSS project management staff in the areas of systems engineering and operations planning and engineering will be provided via support contracts. User oriented analyses on transponder power, communications margins, and interference effects are conducted on a continuing basis to ensure appropriate user support with the TDRSS.

In FY 1982, effort will continue on the design and implementation of the control center for the rephased Space Telescope mission. This work will be conducted in concert with the development of the Science Institute Facilities to minimize the design cost for both hardware and software systems as well as to facilitate testing and other operational activities. The funds requested provide for procurement of the control center hardware and software for telescope pointing support, generation of command sequences for the spacecraft computers, and calculation of spacecraft attitude.

To efficiently and effectively meet the mission control workload in the 1980's, a new approach to control center design **has** been initiated. This approach involves techniques for rapid configuration of control center equipment and software to meet the requirements of multiple missions with the same equipment. The overall objective of the new design is to permit the sharing of resources to improve equipment utilization and to decrease the number of software and operations personnel. In FY 1982, the necessary computer and equipment for automatic configuration will be purchased.

	1980	1981		1982
	<u>Actual</u>	<u>Budget</u> <u>Estimate</u>	<u>Current</u> <u>Estimate</u>	<u>Budget</u> <u>Estimate</u>
		(Thousands of Dollars)		
Deep space network systems implementation.	15,000	23,100	23,100	43,600

OBJECTIVES AND STATUS:

The role of the Deep Space Network (DSN) is to provide the communication link between each of NASA's far distant planetary and interplanetary spacecraft and the Earth. Thus, the DSN is responsible for receiving science data from, and providing the command and control uplink capability to a constellation of spacecraft ranging out to nearly 3.5 billion kilometers from Earth, (an ever-increasing range). In addition, after the Tracking and Data Relay Satellite System (TDRSS) becomes operational, the Deep Space Network will also support spacecraft much closer to Earth. This new set of spacecraft will include highly elliptical Earth orbiters and synchronous earth orbital missions which will be in orbits above the area supported by TDRSS.

The systems and facilities required to accomplish this are highly specialized, and include Deep Space stations with their large aperture antennas (up to 64-meter diameter), ultrasensitive receivers, and high power transmitters. Advanced data handling systems are required both at the stations and in the network control center.

The three major objectives for the Deep Space Network in the 1980's can be summarized as follows: (1) to provide communications channels to scientific spacecraft at ever-increasing distances (to Neptune by the end of the decade) and to provide the capability to receive clear images at these great new distances; (2) to consolidate the activities of the residual spaceflight Tracking and Data Network with the Deep Space Network after TDRSS becomes operational in 1984 - this consolidation will increase operational flexibility and reduce overall operating costs; and (3) to provide support for a new set of spacecraft which will include highly elliptical Earth orbiters and synchronous earth orbital missions (both of which types will be in orbits above the area supported by TDRSS).

These objectives represent a significant challenge to the DSN, as it will be supporting many more spacecraft than in the past, and it will be working at incredible new distances (over 30 Astronomical Units - 3 times the distance to Saturn) by the end of the decade.

The major effort planned during FY 1982 includes design and initial implementation of antenna aperture expansion and array (thus allowing the DSN to reach out to the edges of the Solar system), and expansion of operations at X-band and higher frequencies to both increase the bandwidth available for the return of scientific data, and to avoid the radio

frequency interference which is becoming a problem at the S-band frequencies. Following the Voyager 2 Saturn encounter in August of 1981, the next major planetary encounter will be of Uranus by Voyager 2 in 1986. This encounter will occur some 3 billion kilometers from Earth. At that time, Voyager 2 will be operating at a very high bit rate because it will transmit the first images ever received from a spacecraft at such a distance. The newly consolidated network will receive its first major test of multiple antenna array (more than 2 antennas) during this Uranus encounter. In addition, the design and implementation of the new consolidated network must provide the flexibility necessary to support near-Earth missions that cannot be supported by the Tracking and Data Relay Satellite (TDRSS).

New missions which will be supported by the network in the 1980s include the Venus Orbiting Imaging Radar (VOIR), a Jupiter orbiter and probe-(Galileo), and the International Solar Polar Mission (ISPM). One or more Halley's Comet rendezvous missions will also be supported for the international community.

BASIS OF FY 1982 BUDGET:

Implementation funding for N 1982 provides for the initial phases of the consolidation and collocation of the three Deep Space and adjacent near-Earth (STDN) stations into a modern and highly reliable, automated network. This network will provide enhanced spacecraft-ground telecommunications capability and navigation precision while reducing overall maintenance and operations costs. The initial design and implementation phase of the program provides for design and manufacture of subsystem equipment to be deployed during consolidation of the deep space and near-Earth tracking networks. This equipment provides capabilities such as maximum automation of the operation of the antenna system itself to reduce required manpower. These automated systems will consist of antenna monitor and control, safety, transmission and receiving equipment. *Also* included in the request are funds for the engineering effort and fabrication required to co-locate the antenna structures with a shared signal processing center. Thus, instead of having independent support facilities at three separate locations, all antennas will interface with the single processing center. This center will include the digital electronics required for uplink command encoding, downlink demodulation, signal recording, and data transmission for all of the antennas in the complex. Centralized maintenance facilities will also exist within the shared signal processing area. The overall design will allow antennas to operate either independently (with different individual spacecraft) or in an arrayed fashion (more than one antenna targeted on a single spacecraft) to achieve the increased aperture necessary to support the high data requirements of missions such as Voyager 2 at Uranus. *As* the distance to the spacecraft doubles, the antenna aperture needed to provide an equivalent signal goes up by a factor of four (4) - thus the need for increased antenna aperture at Uranus, which is twice the distance that Saturn is from Earth. While designed to support non-TDRSS compatible missions, emergency backup support to certain mission phases of Shuttle, TDRSS, and other Earth orbiting satellites will be possible with the consolidated network. The design provides improved flight project support capability while achieving substantial reduction in operations and maintenance costs.

In conjunction with the evolution of the consolidated network, modifications are planned at the network control center to facilitate scheduling, spacecraft acquisition and tracking, monitor and control, and overall coordination of the

activities of the network. Funding also provides: continued development and improvement in flight navigation accuracy; development of a new frequency and timing capability utilizing fiber optic technology for signal distribution, and replacement of obsolete frequency and timing equipment.

Concurrent with these important engineering changes, **FY 1982** funds **will** be required to maintain the high level of reliability for support of the time critical **maneuvers** and planetary encounters. This will be accomplished through a continuing program of equipment and facility refurbishment, modification and maintenance to assure compatibility of existing equipment with the new systems being implemented in the network.

	<u>1980</u> <u>Actual</u>	<u>1981</u> Budget <u>Estimate</u>	<u>Current</u> <u>Estimate</u>	<u>1982</u> Budget <u>Estimate</u>
		(Thousands of Dollars)		
Aeronautics and sounding rocket support systems implementation	3,850	4,100	3,500	8,000

OBJECTIVES AND STATUS:

The objective of the aeronautics and sounding rocket support system implementation Program is to provide fixed and mobile instrumentation systems to meet the tracking, data acquisition and range safety requirements of the aeronautical research conducted at the Wallops Flight Center (WFC) in Virginia and the Dryden Flight Research Center (DFRC) in California, and the scientific investigations conducted with balloons and sounding rockets at Wallops and other selected sites around the world. The WFC and DFRC provide the fixed ground instrumentation systems to support aeronautical research. In addition, WFC provides both fixed and mobile instrumentation to support the Sounding Rocket program.

The aeronautical research efforts and scientific experiments using sounding rockets and balloons are programs of a continuing nature which remain at generally the same level of effort from year to year. To support these programs, WFC provides fixed and mobile instrumentation systems; namely, radar, telemetry, communications, command, data handling and processing systems. To maintain these facilities, spare and replacement parts must be acquired and test and calibration equipment must be replaced routinely. Due to the age of some of the radar, telemetry and impact prediction equipment, a phased program of necessary replacement is underway in order to sustain and improve the tracking and data systems support for these programs. To insure the maintenance of an appropriate level of real time collection and handling capability to meet current and future requirements, an orderly plan to replace obsolete equipment **has** been defined and is being implemented. To meet the remote site sounding rocket and balloon support requirements, mobile equipment requires periodic refurbishment and modifications.

CHANGES FROM FY 1981 BUDGET ESTIMATE:

The decrease of \$600,000 in the FY 1981 estimate is due to the Congressional reduction in the FY 1981 appropriation request resulting in a deferral of the **FPS-16** radar modernization at **WC** until FY 1983.

BASIS OF FY 1982 ESTIMATE:

The major portion of aeronautics and sounding rocket support systems budget maintains support instrumentation at a proper and reliable operating level to meet scientific tracking and data requirements at various locations including **DFRC**, **WC** and at foreign sites. The increase Over FY 1982 is requested to fund long overdue replacement computers utilized for impact prediction and related data processing. These were deferred previously in the amended FY 81 budget request.

	<u>1980 Actual</u>	<u>1981 Budget Estimate</u> (Thousands of Dollars)	<u>Current Estimate</u>	<u>1982 Budget Estimate</u>
Communications systems implementation... ..	5,030	5,600	3,100	6,900

OBJECTIVES AND STATUS:

The objective of the communications system implementation program is to provide the necessary capability in NASA's global communications network (**NASCOM**) to meet new program support requirements, to increase the efficiency of the network, and to keep **NASCOM** at a high level of reliability for the transmission of data. **NASCOM** interconnects the tracking and data acquisition facilities which support all flight projects; it also links such facilities as launch areas, test sites, and mission control centers.

The major efforts underway in the **NASCOM** are the implementation of a control and status system that can remotely control the configuration of the **TDRSS** multiplexing system at White Sands and the implementation of a 50 megabits per second transmission capability connecting the White Sands, Johnson Space Center, and Goddard Space Flight Center for support of **Spacelab** and **Landsat-D** missions.

CHANGES OM FY 1981 BUDGET ESTIMATE:

The decrease of \$2.5 million in the FY 1981 funding level is due to the Congressional reduction which will defer the communications terminal required to work with the **Landsat-D** transportable ground station to FY 1982.

BASIS OF FY 1982 ESTIMATE:

The FY 1982 funding requirements will provide the sustaining equipment and modifications to support the NASCOM network and to begin effort on replacement of the message switching system at GSFC to coincide with the TDRSS communications system which will operate at very high data rates.

	1980 <u>Actual</u>	<u>1981</u> Budget Current <u>Estimate</u> <u>Estimate</u>		1982 Budget <u>Estimate</u>
		(Thousands of Dollars)		
Data processing systems implementation	13,900	12,300	12,300	29,300

OBJECTIVES AND STATUS:

The data processing systems implementation program provides for the procurement of equipment and related services for the large computer complexes at the Goddard Space Flight Center (GSFC) which support both the operational and payload requirements of space missions. To meet operational requirements, these computer complexes, utilizing sophisticated software programs, determine spacecraft attitude and orbit, generate commands to the spacecraft that provide the status of onboard subsystems. In support of spacecraft payloads, the computer systems process the data from science and applications experiments for subsequent transfer to the experimenters.

Significant activities in this program continue at GSFC to keep the large computing complexes viable and responsive to project support requirements. The Telemetry On-Line Processing System (TELOPS) is routinely supporting a number of Earth orbiting spacecraft. The Image Processing Facility (IPF) is generating products for Landsat, Heat Capacity Mapping Mission, and Nimbus 7. The program to replace many of the old computers continues. A contract has been awarded to replace the computers which handle metric tracking data and provide a data base for performing orbit computations. Implementation continues on a new system to process data from numerous and varied experiments which comprise the payloads of early Spacelab missions.

BASIS OF FY 1982 ESTIMATE:

The FY 1982 budget request will provide continued funding for phased replacement of the existing computer complex at the GSFC which provides real time support to the many NASA spacecraft. Included in the support are such critical activities as real time attitude and orbit determination, memory management for onboard computers, and flight maneuver control. This computer complex is approximately fifteen years old. Not only are hardware and software maintenance becoming more difficult and expensive, but the more frequent system outages are becoming a threat to spacecraft support. Further, system architecture requires more extensive software development to adapt to new missions.

The FY 1982 funding request provides for continuation of the phased computer replacement program for the flight dynamics system and initial funding for replacement of the command management and orbit computation systems at the GSFC.

Funds are also required to continue implementation of the Spacelab Data Processing Facility. This capability is being provided by augmenting and sharing the existing free flyer data processing capability. The existing Univac 1108 computers which are about 15 years old are being replaced with faster systems, thereby providing the additional capability required to handle the Spacelab data rates. Funds are also requested for upgrading the facility to provide for a more reliable operation for both Spacelab and free-flyer support.

There is a continuing requirement to procure and maintain adequate supplies of spare parts to replace failure prone and high maintenance electronic modules, to provide test equipment, and to undertake minor modifications and hardware fabrication associated with new equipment installation and reconfiguration.

ADVANCED SYSTEMS

BASIS OF FY 1982 FUNDING REQUIREMENTS:

		1980	1981		1982
		<u>Actual</u>	<u>Budget Estimate</u>	<u>Current Estimate</u>	<u>Budget Estimate</u>
			(Thousands of Dollars)		
Advanced systems.....	.....	10,600	11,300	11,300	12,500

ACTIVITIES AND STATUS:

The OSIDS advanced systems program conducts studies and development of tracking and data acquisition systems and techniques required: (1) to obtain new and improved capabilities for the networks and data facilities to meet the needs of approved missions and near-term new starts; and, (2) to improve the cost-effectiveness and optimize the reliability of the overall tracking and data acquisition support for the total mix of spaceflight missions. This includes advanced investigations in support of upcoming missions as well as ground system trade-off studies to determine, for example, which approach would have the lowest life-cycle costs. This information can then be incorporated into support planning for future space missions.

BASIS OF FY 1982 ESTIMATE:

Most of this work is done through contracts at GSFC for the Spaceflight Tracking and Data Network (STDN) and by engineers at JPL for the Deep Space Network (DSN).

Initial studies, development, and prototype tests are undertaken in this program that lead to the implementation of required tracking and data acquisition capabilities for support of NASA flight programs. Over the years, for example, ground based navigation accuracy for deep space missions has steadily increased; in 1977, we were able to guide the Voyager spacecraft to within an aim point at Mars only 60 km square. Efforts are underway to achieve an aim point of 5 km square for support of future planetary launches. Tests and evaluations of these navigation systems are continuing, and in FY 1982, technology for further improvements will be examined.

Telemetry data rates handled by the DSN have increased at an even faster rate to the extent that our present capability can handle 115 kilobits per second from Jupiter distances. Work will continue in this area in FY 1982. It will include efforts on a 30 megabit telemetry receiving system to handle wide-bandwidth radar and video imaging data, on preparations for experimental testing of x-band command uplink developments using the Solar Polar mission, and on automated station operating technology. This development will greatly enhance the amount of science information that can be obtained and, correspondingly, the potential science value of all future investments in planetary missions.

For the near-Earth orbiting satellites, the overall amount of data collected by the **STDN** and processed each day shows how these capabilities have increased to meet the required support workload. **As** we move into the **TDRSS** era, data volume will increase by approximately a factor of four; moreover, we must work on methods to deliver mission data primarily in a real time mode to numerous and widely dispersed users. Included in **FY 1982** will be effort in: techniques for increased onboard autonomy including pre-processing of the telemetry data stream before **it is** transmitted from the **TDRSS** user spacecraft; and the development of wideband 100 megabit, communications links to eliminate the need for store and forward operations at the **TDRSS** ground terminal. Work continues on testing fiber optics as a means of distributing high data rates (up to 50 **Mbs**) between computers and payload processing centers.

Effort will continue in **FY 1982** on frequency standards, to improve synchronization of clocks at stations around the world and on board the spacecraft, and to accurately measure intercontinental base lines. These systems have enabled NASA to figuratively tie together, in time and space, every accessible place in the solar system. The new and improved tracking techniques that these improvements make possible are vital for missions to the outer planets and their satellites because of the extreme navigation accuracies that such missions require.

NASA HEADQUARTERS



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FISCAL YEAR 1982 BUDGET ESTIMATES